JUL 28 1921
BUREAU OF STANDARDS
LIBRARY

JULY 15, 1920 PRICE 25 CENTS

AVIATION AND AERONAUTICAL ENGINEERING

The Aeromarine F-5-L 10-Passenger Flying Yacht, Recently Launched

VOLUME VIII
Number 12

SPECIAL FEATURES

DYNAMIC LIFT AND CEILING FOR AIRSHIPS
THE PACKARD 500-600 HP. AIRCRAFT ENGINE
AERONAUTIC INSTRUMENTS
EFFICIENCY OF AIRPLANE STRUTS
THE FAIRCHILD AUTOMATIC CAMERA

Three Dollars a Year

PUBLISHED SEMI-MONTHLY
BY
THE GARDNER, MOFFAT CO., INC.
HIGHLAND, N. Y.
HARTFORD BUILDING, UNION SQUARE
22 EAST SEVENTEENTH STREET, NEW YORK

Entered as Second-Class Matter, May 19, 1920, at the Post Office at Highland, N. Y., under Act of March 3, 1879.

CLIMAX Mo-lyb-den-um The Commercial Alloy

What Makes An Alloy Steel "Commercial"?

The total cost of the finished product of the quality required

Our book, "Molybdenum Commercial Steels" through the aid of photomicrographs, colored heat treatment charts and other data derived from the commercial production and consumption of several score thousand tons of these steels, shows why they are termed "commercial."

Copies may be obtained by addressing

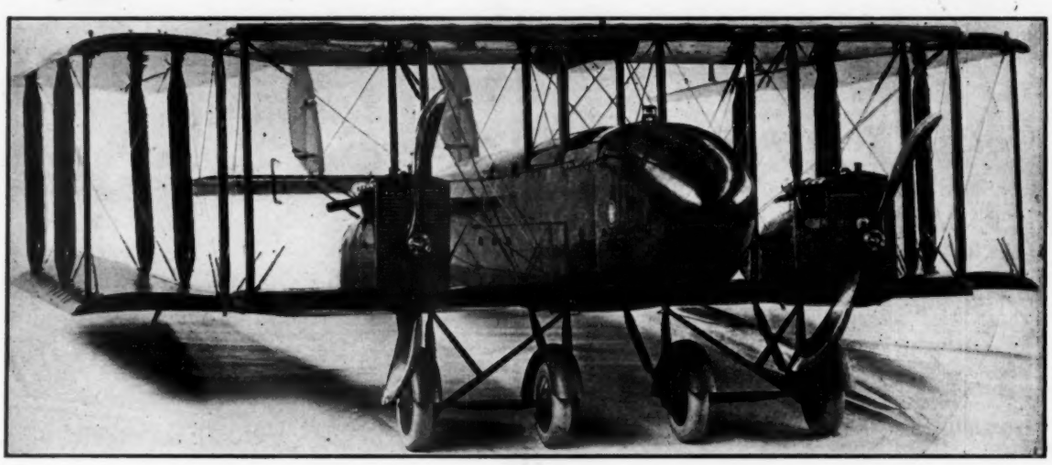
Climax Molybdenum Co.
or
The American Metal Co., Ltd.
61 Broadway, New York

Molybdenum Steels

Easier to Heat Treat
Easier to Machine
Dynamically Tougher
Resist Fatigue —

PROVEN IN WAR FOR THE TASKS OF PEACE

One of the Glenn L. Martin Company's latest developments
The New Mail and Express plane with folding wings. Wing Spread 71 ft.-5 in. Spread with wings folded 35 ft.-10 in.



From Novelty Through Battle To Earning Capacity

THE story of the Martin Airplane is brief from a standpoint of time. Hardly more than a sensational novelty when it demonstrated its value in war, it is now on its way to commercial supremacy.

In 1919 the Commercial planes of England made twenty-one thousand flights, traveled over three hundred and three thousand miles and carried fifty-two thousand passengers without accident.

Out of its remarkable experience gained in Government Service the Glenn L. Martin Company has developed the Airplane for Commercial purposes in America, as well as for pleasure flying.

Equipped with two 12 cylinder 400 h.p. Liberty Motors the Glenn L. Martin Commercial plane develops the highest speed of any plane of its type, the fastest climbing ability of any plane of its size and weight.

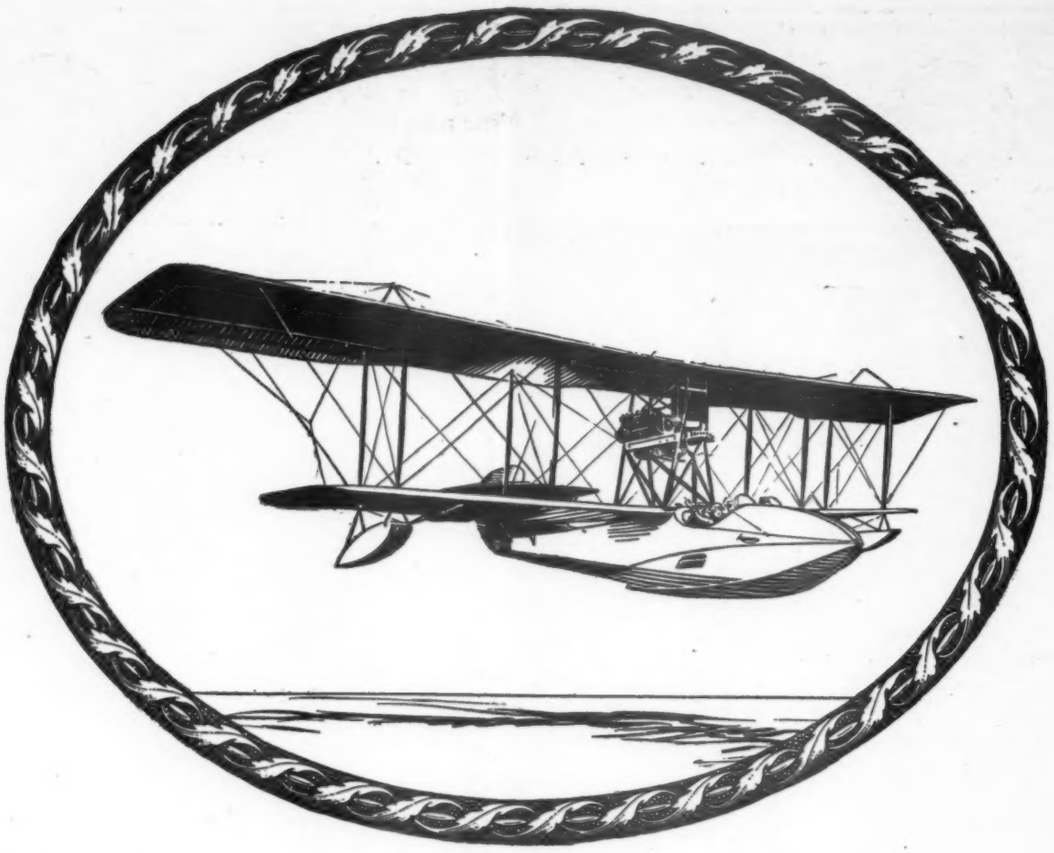
The Glenn L. Martin Company will welcome inquiries and will be glad to furnish exact figures showing the earning capacity of Martin Airplanes in transportation problems where ordinary methods prove inadequate.

The Glenn L. Martin Company

Cleveland, Ohio

Contractors to the United States Army, Navy and Post Office Department

Member of the Manufacturers Aircraft Association



Double Revenue from Aeromarine Agency

WE can give you the facts on how dealers make money on Aeromarine agencies.

One Season pays for your own boat, just in cash receipts for flights.

And add to that all you make on actual sales—increasing every day—as the progressive American business man wakes to the fact that here is the new way of getting there—the faster, cleaner, cooler way—the ultimate in luxury.

No wonder the Aeromarine demonstration is the one that sells the prospect every time.

Write us today of dealer opportunities—before the cream of the business has been taken by the men of vision.

Aeromarine

AEROMARINE PLANE & MOTOR CO., TIMES BUILDING, NEW YORK
LARGEST EXCLUSIVE BUILDERS OF FLYING BOATS IN AMERICA

"The Motor That Made the Spad Possible"
RELIABILITY
THE consistent, hour-after-hour reliability of the Wright-Hispano Aeronautical engine is proverbial.
For five years it proved its merit—justified its design — as the leading aeronautical engine of the Great War.
Powering the newer designs of commercial and sporting airplanes, flying boats and seaplanes, Wright-Hispano brings to such craft a new standard of performance—a greater degree of flexibility—which is characteristic of this great motor.
There are available for immediate delivery 180 H. P. (Model E) Engines to recognized plane manufacturers and responsible owners.
WRIGHT
Aeronautical Corporation
Paterson N.J.
Member Manufacturers' Aircraft Association
Dayton-Wright Aerial-Coupe Model O-W Powered with 180 H. P. Wright-Hispano Aeronautical Engine
WRIGHT-HISPANO
AERONAUTICAL ENGINE
STANDARD MOTOR POWER FOR AIRPLANES, FLYING BOATS, SEAPLANES

NON-STOP RECORD

Omaha to Philadelphia

(About 1,200 Miles Air Line)

Made June 27

By

JL-6 All-Metal Monoplane

Equipped With 185 H.P. Motor

Some of the J.L.-6's Recent Flights:

SPEED RECORD

With Six Passengers
Flew 130 Miles
In 59 Minutes
Atlantic City to Philadelphia
and Back

ALTITUDE RECORD

With Five Passengers
Flew 140 Miles
Climbed 20,600 feet
In 1 Hour 37 Minutes
On June 1.

ECONOMY RECORD

With 8 Passengers
Flew 130 Miles
In 1 hr. 28 min.,
Using 12 1-2 gal. gas,
Costing $3.00

TOURING RECORD

Carried Five Passengers
Washington to New York
248 Miles
In 145 Minutes
On June 13.

WATCH OUR NEXT PERFORMANCE

J. L. Aircraft Corporation

347 Madison Ave., New York City

AVIATION AND AERONAUTICAL ENGINEERING

JULY 15, 1920 VOL. VIII. NO. 12

Member of the Audit Bureau of Circulations

INDEX TO CONTENTS

Editorials	465	Aeronautic Instruments	473
Dynamic Lift and Ceiling for Airships	466	The Efficiency of Airplane Struts	477
N. A. C. A. Reports	469	The Fairchild Automatic Camera	478
The Packard 500-600 Hp. Aircraft Engine	470	Airship Suspensions	479
Farman Goliath in 24-Hr. Flight	472	The Stout Batwing Monoplane	479
		The Advisory Committee for Aeronautics	480

THE GARDNER, MOFFAT COMPANY, Inc., *Publishers*

HIGHLAND, N. Y.

HARTFORD BUILDING, UNION SQUARE, 22 EAST SEVENTEENTH STREET, NEW YORK

SUBSCRIPTION PRICE: THREE DOLLARS PER YEAR. SINGLE COPIES TWENTY-FIVE CENTS. CANADA, THREE AND A HALF DOLLARS. FOREIGN, FOUR DOLLARS A YEAR

COPYRIGHT 1920, BY THE GARDNER, MOFFAT COMPANY, INC.

ISSUED ON THE FIRST AND FIFTEENTH OF EACH MONTH. FORMS CLOSE FIVE DAYS PREVIOUSLY. ENTERED AS SECOND-CLASS MATTER MAY 19, 1920, AT THE POST OFFICE AT HIGHLAND, N. Y., UNDER ACT OF MARCH 3, 1897.

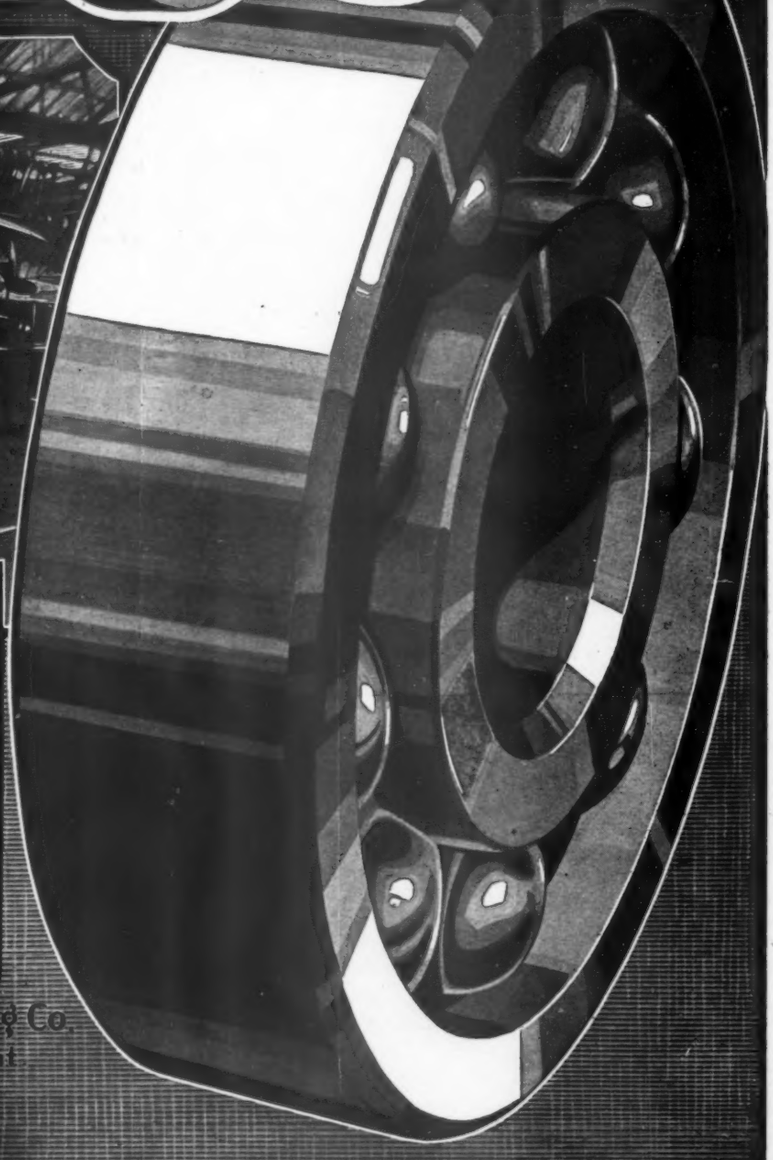
THOMAS-MORSE AIRCRAFT CORPORATION

Thomas-Morse Training 2-Seater in flight over Ithaca, N. Y.

THOMAS-MORSE AIRCRAFT CORPORATION

NEW DEPARTURE

Ball Bearings



THE selection of New Departures for airplane installations in present day machines is as much the result of observation of war time service as competitive laboratory tests. New Departure superiority is as marked in one as the other.

CONRAD PATENT LICENSES

New Departure Manufacturing Co.
Bristol, Connecticut
Chicago Detroit

L. D. GARDNER
PRESIDENT AND EDITOR
W. D. MOFFAT
VICE-PRESIDENT
W. I. SEAMAN
TREASURER
H. M. WILLIAMS
GENERAL MANAGER

AVIATION
AND
AERONAUTICAL ENGINEERING

ALEXANDER KLEMIN
TECHNICAL EDITOR
LADISLAS D'ORCY
ASSOCIATE EDITOR
GEORGE NEWBOLD
BUSINESS MANAGER

Vol. VIII July 15, 1920 No. 12

LITTLE has been written of this phase of the study of lighter-than-air craft. In this issue the subject is considered quantitatively by a writer who finds some important uses for this force, which has hitherto been regarded as a disturbing factor in the operation of airships.

As in airplanes the stabilizer and elevator surfaces are not used to obtain lift directly but only as a means of controlling the angle of pitch which, as in the airplane again, is about 15 deg. for the maximum lift.

In addition to the increased ceiling available with the aid of dynamic lift, a number of methods for using it to improve the maneuvering properties are discussed. The amount of ballast and gas lost may also be reduced. In this way, the efficiency of the ship is directly improved, as the reduction in ballast to be carried means a greater useful load which may be attained at the expense of a slightly increased fuel consumption.

As the size of the ship increases, the relative dynamic effect slowly diminishes, but this occurs at a lesser rate than the disposable lift.

Plywood Exposed to Oil

There has been hesitation shown in some quarters over the use of plywood in places where it is exposed to gasoline and oil. A forty-five weeks' test at the Forest Products Laboratory, in which the plywood was kept immersed in gasoline, motor oil, and castor oil, showed that the glued joints were not greatly weakened. The shear strength did not fall below 125 lb. per sq. in., which is sufficient for ordinary service conditions. Although the wood absorbed from sixty to seventy per cent of its weight in gas and oil, no swelling was noticed. This is a valuable indication.

Unequal Loads on Wings

The effect of certain maneuvers or gusts is to impose greater loads on the wings on one side of an airplane than on the other. Accelerometer tests show only the average of the wing loads, and there is some doubt as to what the difference is on right and left sides.

A test conducted at McCook Field showed that the effect of unequal loading on the right and left wings of a biplane was such as to affect the overall factor of safety very little. Starting with the same load on both sides, the load on the left side was increased by one-half a factor of safety, while the right side was next made equal to and then a half factor heavier than that on the left. The process was then repeated with the left side so that the load on each side in turn was made equal to and then a half a factor of safety heavier than that on the other side. The tension in the lift wires was measured with a Larson tensiometer in order to determine how the stresses were being distributed.

With a factor of 7.5 on the left side and 7.0 on the right, the upper rear spar failed in bending about 20 inches outside of the center section strut station.

A similar set of wings had been previously tested and the difference in the factor of safety carried in the two tests agreed closely with the strenghts of the material in the two sets of wings.

The conclusion reached is that a biplane wing structure can sustain unequal loads on either side without much reduction in factor of safety.

Comfort in the Cockpit

In spite of all attempts at stadardization, the design of the cockpit still varies in every machine. It is interesting to see how careful some English designers are in attempting to secure the maximum possible comfort. In one case wet plaster of Paris casts were employed to obtain sound anatomical lines for the wicker seat. Instead of striking a happy mean for the length of a pilot's legs, the same designer obtained adjustment by a very simple means. The seat is supported on a plywood shelf, carried in its turn on spruce bearers which are attached by bolts and tubular rivets to vertical tubular fuselage struts. Four bolts furnished with fly nuts are attached to the seat and are free to slide in slots in the plywood shelf. These apparently minor details in design have real importance for machines which are to be in constant use.

Small Commercial Airships

The small commercial airship which is illustrated in our present issue affords an interesting indication of the adaptability of lighter-than-air craft to the manifold needs of commercial aeronautics.

This craft was originally designed to serve for gun spotting in connection with fleet work, it being deemed that the greater mobility of an airship would enable it advantageously to replace the captive kite balloon. While this supposition has yet to be substantiated by exhaustive trials—which, we understand, are at present under way—the small vessel proved somewhat of a revelation in that it possessed, despite its small capacity and horsepower, good maneuverability, speed and endurance.

The adaptation of the type for air transport of a special nature, where not more than two persons have to be carried at a reasonable turn of speed and with the possibility of examining the underlying ground at leisure, was therefore a logical sequel to this development. This is a function which the airplane cannot fulfill to entire satisfaction because its high speed interferes with a detailed inspection of the ground; furthermore, the vision from the car of an airship is much less obstructed than that an observer can possibly obtain from the fuselage of an airplane.

The ship illustrated has been put into service to permit the supervision of extensive cotton plantations, where mounted observers were employed up to the present.

Dynamic Lift and Ceiling for Airships

By Alexander Klemin

Consulting Engineer, Aerial Mail Service, Consulting Aeronautical Engineer

The mathematical theory of the airship—whether equipped with ballonets or not—is practically complete as regards altitude maneuvers. But the dynamic effects on the airship both in maneuvering and in turn on ceiling have not been considered hitherto. At the suggestion of Comdr. J. C. Hunsaker, a brief, non-mathematical exposition of this subject is undertaken in the present paper, with special reference to two well known examples of the rigid and non-rigid types.

Some Useful Formulae

Lifting Power of Hydrogen at Standard Atmosphere

$F = 1.1\,V$

where F = lift in kg.

V = volume of bag in cu. m.

Standard Atmosphere and Air Density

Standard atmosphere is that found at sea level in latitude 45 deg. and at a temperature of 0 deg. Cent. under which conditions the pressure is 1.033 kg. per sq. m. where no water vapor is present, and is equivalent to the pressure of a column of mercury 760 mm. in height. The weight of air under standard conditions is 1,293 kg. per cu. m.

Halley's Formula

$H = 18400 \times \log (P_o/P)$

where H is height in m.,

P_o is pressure of standard atmosphere.

P is pressure at height under consideration and temperature variation is neglected.

Density of Air at Altitude

$H = 18400 \log (D_o/D)$

where H = height in m.

D_o = density at altitude considered where temperature variation is neglected.

Weight of Air Displaced by a Balloon at Any Altitude

$H = 18400 \log (W_o/W)$

where H = height in m.,

W_o = weight of air displaced by balloon at sea level,

W = weight of air displaced by balloon at altitude considered and temperature variation is neglected.

Law of Delestage for a Full Balloon

$H = 18400 \log [F \quad (F_o - f)]$

where H = altitude in meters of ascent due to rupture of equilibrium.

F_o = total ascensional force at ground level.

f = ballast thrown overboard or rupture of equilibrium and temperature effects are neglected.

Loss of Gas During Ascent of a Full Balloon

Loss of lift in ascending to any altitude is equal to the buoyancy of the gas lost during the rise.

Altitude at Which a Flabby Balloon Becomes Full

$H = 18400 \log (V/V')$

where V = volume of balloon and V' the volume of the gas in the balloon at the start.

Calculations for Dynamic Lift on a Typical Dirigible of the Non-Rigid Type

The subject is best treated by concrete application to a definite case, and the non-rigid selected is the well-known British Admiralty S. S. Z., a small airship of the Blimp type, with a 100 hp. engine and a pusher propeller. This is illustrated in Fig. 1.

Model Dimensions of the S. S. Z.

MODEL 1/50 TH FULL SCALE

Total length	869 mm.
Maximum diameter	183 mm.
Fineness ratio	4.75
Volume of model	15046 cu. cm. or 0.532 cu. ft
Distance of center of volume from nose	379 mm.
Distance from the nose, measured parallel to the airship axis, of the hinge position of the fin flaps	714 mm.
Distance from the nose, measured parallel to the airship axis, of the point of intersection of the moments axis with the envelope (for all positions of pitch)	379 mm.

DIMENSIONS OF FULL SIZED AIRSHIP

Nominal volume of full-sized airship	70,000 cu. ft.
Volume of airship calculated from drawing	66,500 cu. ft.
Distance from the nose, measured parallel to the axis, of the center of gravity of full sized airship	19.33 m.
Distance measured parallel to axis of the c.g. of full sized airship	3.013 m.
Ballonets (2)	500 cu. m. total volume
Useful load	1760 lb. (approximately)
Maximum speed	77 km. per hr. (approximately)
Cruising speed	55 km. per hr. (approximately)
Endurance at maximum speed	12 hr.
Endurance at cruising speed	24 hr.
Ceiling	2400 m.
Engine, Rolls Royce Hawk	75 hp.

When the non-rigid is used as a full balloon, it may be made to ascend by an initial rupture of equilibrium, produced by throwing so much ballast. For a ship such as the one described, it is interesting to investigate to what altitude it can rise when no ballast is thrown overboard initially.

When acting as a full balloon with an initial rupture of equilibrium, the airship rises with loss of gas, until the decrease in lifting power balances the initial rupture of equilibrium.

When elevators are employed, a dynamic lift can be imparted to the ship which will enable it to rise to a certain height without initial throwing over of ballast.

At this position of equilibrium there will be a moment equilibrium with the couple due to buoyancy balanced by the

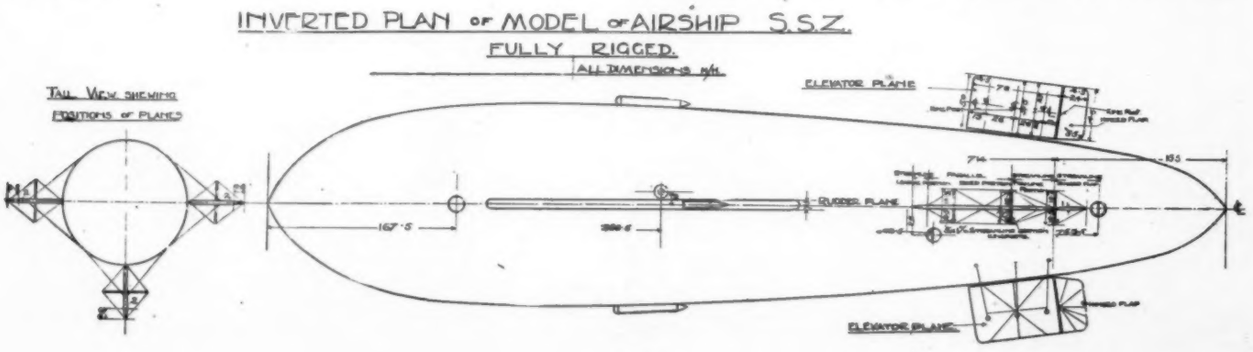


FIG. 1.

propeller thrust and the moment due to dynamic forces, as illustrated in Fig. 2. Since the airship no longer rises, the inclination of the axis with the horizontal is also the angle of incidence or of pitch of the airship. The variation in engine power due to density variation may be neglected for the comparatively small change in altitude, as also the variation in dynamic lift due to change in density, since this is small compared to the change in buoyancy.

As an illustrative example, suppose the airship has an angle of pitch of 8 deg. in its final position of equilibrium, after rising from the ground with no initial rupture of equilibrium

Assuming that the wind tunnel drag values of the airship fully rigged require no appreciable correction for full scale effect, and that the best efficiency of the propeller is 75 per cent, the maximum speed with a 75 hp. engine and a drag on the model of 0.1319 lb. at 40 ft./sec. and 8 deg. incidence is 53 ft/sec. or about 36 m.p.h. (which is somewhat lower than the actual test speed.) The gross weight is $66{,}500 \times 70/1000 = 4650$ lb. Since the useful load is 1760 lb. and the approximate position of useful load is 15.0 cm. from axis on the model or 7.5 m. on the airship, the center of gravity is

$$\frac{3.013\ (4650 - 1760) + 1760 \times 7.5}{4650} = 4.71 \text{ m.}$$

The buoyancy couple is therefore

$4.71 \times 3.28 \times 4650 \times \sin 8 \text{ deg.} = 10{,}000$ ft. lb.

Neglecting the moment of the offset propeller the corresponding pitching moment on the model must be at 40 ft./sec., where v is the speed of the dirigible $\frac{10{,}000}{50^3} \times \frac{40^3}{v^3} \times 12$ in. lb.

Assuming as a first approximation that the speed of 53 ft./sec. remains unchanged, moment is $\frac{10{,}000}{50^3} \times \frac{40^3}{53^3} \times 12 = .556$

The moment axis on the model test is sufficiently close to the center of gravity, so that no conversion of moments is necessary. The positive or stalling moment of the airship with zero angle of incidence is 0.66. The elevators would actually have to be set at a small positive angle, as this stalling couple would be slightly greater than the buoyancy diving couple.

The lift of the model under these conditions is .0179 lb. Since the airship is no longer climbing and the angle of incidence is small the entire lift is balanced by the change in buoyancy, and the amount of the lift is

$$\frac{.0179 \times 50^2 \times 53^2}{40^2} = 79.6 \text{ lb.}$$

This is the equivalent of 1.7 per cent of the entire load, which is a somewhat low value for the initial rupture of equilibrium of a free balloon.

This corresponds to an altitude given by the law of delestage

$$18400 \log \frac{100}{100-1.7} \times 3.28 = 5000 \text{ ft.}$$

To Find Altitude of Maximum Dynamic Lift for the S. S. Z., When No Longer Climbing, at Altitudes Near the Ground

Just as for the airplane there is an altitude at which the machine has a maximum rate of climb, so for the airship there must be an altitude of maximum dynamic lift. We will investigate this altitude at ground level.

The problem is slightly more complicated than that of the airplane, because the resistance coefficient of the airship varies

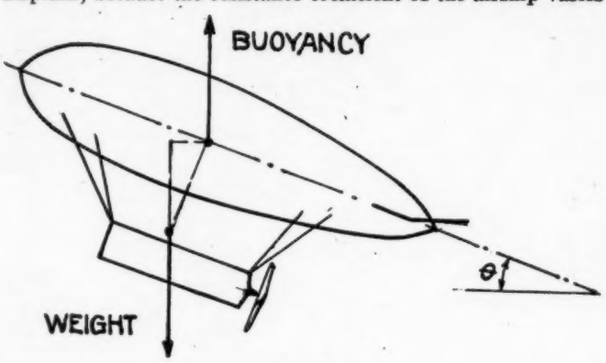


FIG. 2.

TABLE I.

TESTS OF AIRSHIP S.S.Z. (FULLY RIGGED).

Drag Forces on Model with the Body set at various Angles of Pitch and the Elevators at various Angles of Attack.

Rudder at 0°. Drag Forces (lb.). Wind Speed 40 ft./sec.

Angle of Pitch	Setting of Elevators.						
	0°	+12°	+24°	+36°	−12°	−24°	−36°
−4	0.1037	0.1081	0.1129	0.1159	0.1132	0.1313	0.1439
−2	0.1034	0.1089	0.1147	0.1182	0.1075	0.1221	0.1361
0	0.1020	0.1091	0.1166	0.1221	0.1065	0.1163	0.1284
+2	0.1035	0.1124	0.1209	0.1284	0.1076	0.1141	0.1236
4	0.1086	0.1182	0.1271	0.1386	0.1103	0.1153	0.1234
6	0.1178	0.1276	0.1425	0.1525	0.1164	0.1189	0.1260
8	0.1319	0.1432	0.1596	0.1716	0.1261	0.1263	0.1323
10	0.1483	0.1625	0.1829	0.1968	0.1405	0.1408	0.1448
12	0.1697	0.1855	0.2091	0.2254	0.1609	0.1603	0.1623
14	0.1958	0.2166	0.2390	0.2601	0.1832	0.1808	0.1834
16	0.2252	0.2570	0.2761	0.2972	0.2092	0.2072	0.2092
18	0.2589	0.2989	0.3205	0.3405	0.2392	0.2363	0.2374
20	0.2999	0.3474	0.3674	0.3855	0.2691	0.2679	0.2673

TABLE II.

TESTS OF AIRSHIP S.S.Z. (FULLY RIGGED).

Lift Forces on Model with the Body set at various Angles of Pitch and the Elevators at various Angles of Attack.

Rudder at 0°. Lift Forces (lb.). Wind Speed 40 ft./sec.

Angle of Pitch.	Setting of Elevators						
	0°	+12°	+24°	+36°	−12°	−24°	−36
−6	−0.090	—	—	—	—	—	—
−4	−0.052	−0.016	+0.012	+0.014	−0.104	−0.169	−0.193
−2	−0.020	+0.019	0.049	0.051	−0.069	−0.137	−0.149
0	+0.005	0.056	0.088	0.095	−0.034	−0.100	−0.107
+2	0.049	0.095	0.133	0.140	+0.003	−0.057	−0.067
4	0.078	0.135	0.180	0.182	0.043	−0.010	−0.024
6	0.129	0.188	0.229	0.232	0.084	+0.032	+0.023
8	0.179	0.244	0.277	0.287	0.135	0.076	0.072
10	0.236	0.296	0.339	0.352	0.191	0.134	0.127
11	0.266	0.325	0.366	0.411	0.223	0.167	0.156
12	0.298	0.351	0.399	0.431	0.253	0.202	0.190
13	0.329	0.384	0.429	0.463	0.278	0.232	0.236
14	0.361	0.421	0.462	0.491	0.306	0.257	0.289
15	0.390	0.451	0.497	0.527	0.330	0.283	0.321
16	0.421	0.477	0.525	0.559	0.355	0.312	0.348
18	0.472	0.541	0.582	0.614	0.413	0.359	0.402
20	0.515	0.595	0.650	0.661	0	0.397	0.439

TABLE III.
TESTS OF AIRSHIP S.S.Z. (FULLY RIGGED).

Pitching Moments on Model with the Body set at various Angles of Pitch and the Elevators set at various Angles of Attack.
Rudder at 0°. Pitching Moment (lb. in.). Wind Speed 40 ft./sec.

Angle of Pitch.	Setting of Elevators.						
	0°	+12°	+24°	+36°	—12°	—24°	—36°
—4	——	—1.22	—1.49	—1.48	—0.08	+0.65	+0.98
—2	—0.43	—0.94	—1.21	——	+0.19	0.83	1.06
0	—0.11	—0.68	—0.97	—1.06	0.44	0.92	1.07
+2	+0.20	—0.51	—0.77	—0.96	——	1.16	1.28
4	0.37	—0.33	—0.62	—0.83	0.93	1.38	1.49
6	0.53	——	——	——	——	——	——
8	0.66	—0.15	—0.61	—0.78	1.21	1.63	1.70
10	0.67	——	——	—0.92	——	1.66	1.72
12	0.64	—0.21	—0.82	—1.22	1.21	1.51	1.65
14	0.43	—0.27	—0.85	—1.29	1.22	——	1.23
16	0.40	—0.47	—1.00	—1.34	1.17	1.38	1.06
18	0.34	—0.55	—1.13	—1.44	——	——	1.09
20	0.34	—0.63	—1,21	—1.48	1.17	1.40	1.24

TABLE IV.

Angle of Pitch	Buoyancy Couple (ft./lb.) Diving Moment)	Drag co-efficient with elevator at zero	Approximate speed with maximum propeller efficiency (ft./sec.)	Propeller efficiency	Approximate speed with correction for propeller efficiency (ft./sec.)	Equivalent couple on model	Approximate setting of elevator required to balance buoyancy couple at this speed	Lift coefficient with zero elevator setting	Dynamic Lift with zero elevator setting (lb.)	Lift coefficient with elevator setting as in table	Dynamic Lift with setting of elevators as in table (lb.)
0	0	.1020	58				0				
2	—2500	.1035	57.5	75.0	57.5		0	.0490	318		
4	—5000	.1086	56.6	73.8	56.5	+.2400	0	.0780	388		
6	—7460	.1178	55.3	72.7	54.7	+.3820	0	.1290	600		
8	—9950	.1319	53.2	71-8	52.3	+.5600	0	.1790	790		
10	—12400	.1483	51.1	69.0	49.6	+.7720	0	.2360	986		
12	—14800	.1697	49.0	67.3	47.0	+1.2350	—12°	.2980	1022	.253	945
14	—17400	.1958	46.5	65.5	44.5	+1.3500	—12°	.3610	1130	.306	1040
16	—19700	.2257	45.5	64.4	42.2	+1.7000	—24°*	.4210	1170	.312	1020
18	—22100	.2589	42.5	61.7	39.6	+2.1600	—24°	.4720	1123	.359	1020
20	—24400	.2999	40.5	60.0	37.6	+2.6500	—24°	.5150	1130	.397	1000

* At these angles couples obtainable from elevators are insufficient to maintain the angle of pitch.

not only with the altitude or angle of incidence of the ship, but also with the setting of the elevators, which may have to be placed at a considerable angle so as to counteract the buoyancy couple.

A separate calculation must therefore be made for each angle of incidence, as in the proceeding section for angle of incidence of 8 deg.

For the sake of simplicity the engine is taken to deliver 75 hp. throughout the working range, and the propeller to have an efficiency of 75 per cent at 40 m.p.h., and this efficiency to diminish to 50 per cent at 20 m.p.h. The drag, lift and pitching moment for the model S. S. Z. are given in Tables I, II, and III.

The calculations are by no means rigorously exact, since to have them rigorously exact would require a very lengthy process.

A study of these tables gives a number of interesting results. Thus, at smaller angles of pitch the restoring couple due to buoyancy is practically equal to the disturbing couple due to the natural instability of the airship. The elevators will scarcely have to be used at all to maintain any required pitch angle. At higher angles of pitch beyond 14 deg, comparing Table IV with Table III, it is seen that the elevators when displaced to as large a negative angle as is practicable, are not sufficient to counteract the restoring couple due to buoyancy. At such an attitude, it is essential to use ballonets, a moving weight, or a displacement of the car relative to the ship. The approximate speeds of the ship have been calculated with allowance made for decrease in propeller efficiency with decrease of speed. The dynamic lift for each angle of pitch has been calculated with zero elevator setting (assuming moments to be provided by ballonets) and with definite negative settings of the elevators. When the elevators are considered as being at zero there is a definite maximum dynamic lift in the neighborhood of 14 deg. If the elevators are set at a negative angle apparently the maximum dynamic lift occurs at about the same angle.

It is interesting to note the maximum dynamic lift is (1170/4650) 100 = 25.2 per cent of gross lift, indicating that the airship can make with ease a clean get-away without initial use of ballast, and could achieve theoretically quite a respectable ceiling without use of ballast.

Increase in Ceiling Possible for the S. S. Z. by Means of Dynamic Lift

With ballonets of 500 cu. m., the proper proportion of ballast is 550 kg. Assuming this to be carried, and the volume of airship to be 66,500 cu. ft, the gross weight is $\frac{66{,}500 \times 1.1}{1.308 \times 27}$ = 2080 kg.

By the law of delestage

$$H = 18400 \log \frac{2080}{2080 - 550} = 2480 \text{ m.} = 8000 \text{ ft.}$$

is the static ceiling.

If the engine torque is taken as directly proportional to the density, then if approximately the same r. p.m. is maintained at altitude, the speed of the airship will remain approximately the same at altitude. This is the most conservative assumption to make and only with an engine specially designed or adjusted for altitude work would it be possible to increase the speed at altitude. Under such a condition, the dynamic lift would vary directly as the density.

If H = dynamic ceiling in m.

$$H = 18400 \log \left(\frac{F}{F - f - L}\right)$$

where F = total gross weight initially = 2080 kg.

f = ballast = 550 kg.

L = dynamic lift at the ceiling = $L_o\rho$ where ρ is density at the ceiling

L_o = dynamic lift at ground altitude = 1170/2.2 = 532 kg. (as calculated in previous paragraphs)

F = 2080 kg.

This equation can be readily solved by a process of trial and error, and the solution is approximately 4200 m. The theoretical dynamic ceiling is therefore approximately 1720 m. greater than the dynamic ceiling.

Contribution of the S. S. Z. Hull to the Lift

The airship model tested, as illustrated in Figs. 1 and 2, is equipped with horizontal tail surfaces of approximately 9800 sq. mm. Neglecting the lifting effect of the car and rigging, Table V gives us an idea of the proportion of lift due to the hull alone:—

TABLE V.

Angle of Pitch	Lift of Hull at 40 ft./sec.	Lift of Hull as percentage of gross lift	Lift of completely rigged ship elevators at zero	Lift due to horizontal surfaces, car, and rigging
0	0.000	0	0.005	0.005
4	0.022	29.2 per cent	0.078	0.056
8	0.048	26.8 per cent	0.179	0.131
12	0.090	30 per cent	0.298	0.208
16	0.140	33.2 per cent	0.421	0.281
20	0.203	39.6 per cent	0.515	0.312

From this table it is evident that for a non-rigid ship of standard design, the lifting effect of the horizontal tail surfaces, car and rigging is two or three times as great at 12-14 deg. incidence as the effect of the hull. It is therefore mainly by the action of the horizontal tail surface that dynamic lift may be obtained at those altitudes at which a ship will be placed to obtain maximum dynamic lift.

N. A. C. A. Reports

PRELIMINARY REPORT ON FREE FLIGHT TESTS. Synopsis of Report No. 70. National Advisory Committee for Aeronautics.

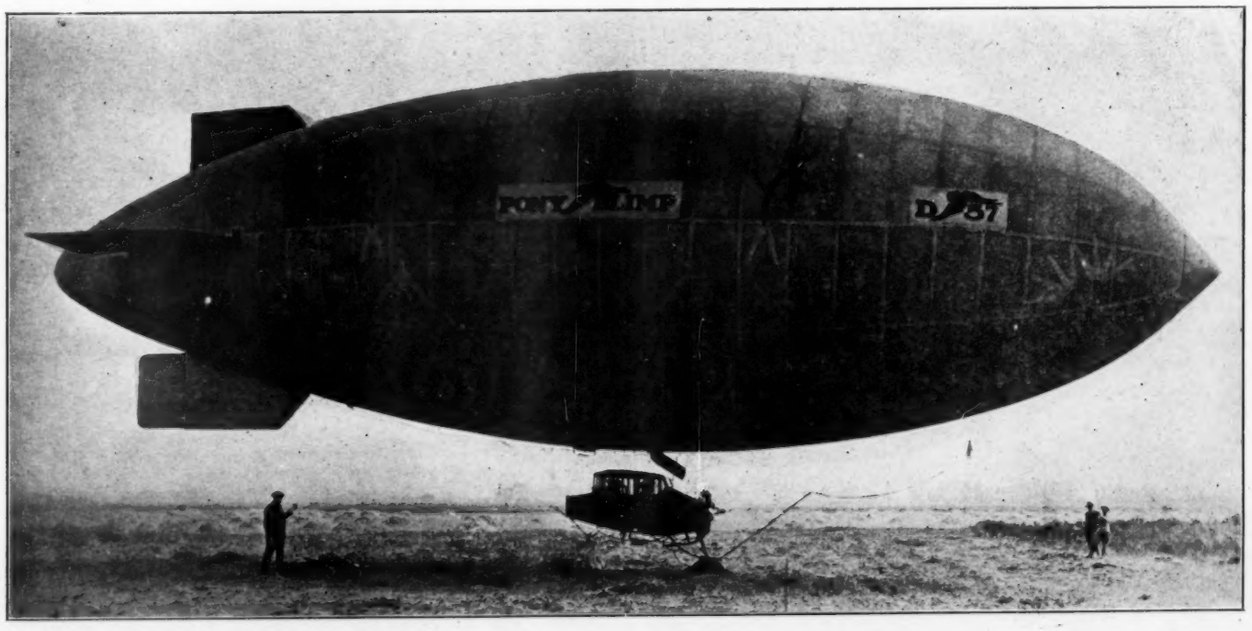
A report of the free flight tests conducted by the National Advisory Committee for Aeronautics to determine some of the characteristics of two full sized JN-4H airplanes. The maximum lift coefficient was found to be about 15 per cent higher in free flight and came at about 4 deg. larger angle of incidence than on the model, and it was possible by using full power to just reach the burble point in level flight. The machines in landing did not exceed an angle of about 12 deg. so that the landing speed deduced from the maximum lift coefficient of the model will in this case give the landing speed very closely. The maximum L/D of the machines was between 7 and 8 which is very near to that of the model. The velocity of the slip stream was determined for several motor speeds and the results agreed well with theoretical values. The longitudinal stability with locked and free controls was investigated for a JN-4H and also a DH-4. While the former machine was found to be quite unstable, the DH-4 was stable.

WIND TUNNEL STUDIES IN AERODYNAMIC PHENOMENA AT HIGH SPEED. Synopsis of Report No. 83, National Advisory Committee for Aeronautics.

A great amount of research and experimental work has been done and fair success obtained in an effort to place airplane and propeller design upon an empirical basis. However, one cannot fail to be impressed by the apparent lack of data available toward establishing flow phenomena upon a rational basis, such that they may be interpreted in terms of the laws of physics.

With this end in view it was the object of the authors to design a wind tunnel differing from the usual type especially in regard to large power and speed of flow, which involves features whose suitability cannot be predicted. After all available information has been secured on full size and model wind tunnels in various parts of the world, there remains much obscurity about the air flow phenomena. It is the assumption of Dr. George de Bothezat that the type of air flow which establishes itself is governed by the stresses set up in the air passing the aerofoil. The unit stresses increase as the velocity rises, and it is easy to conceive that a given type of flow is possible only so long as the shearing stresses developed in the fluid do not exceed a certain magnitude, which depends on the value of the viscosity coefficient.

Experimental investigation of the flow has heretofore been rather unsuccessful because of lack of adequate methods. The writers laid out the design of the McCook Field wind tunnel to investigate the scaling effect due to high velocities of propeller aerofoils. During the course of the experiments, however, it was found possible to visualize the air flow by the following method: The velocities of the air flow discovered by the writers offers a solution to one of the fundamental problems of aerodynamics. This problem is the quantitative empirical measurement of the phenomena of fluid dynamics pertaining to flight and air flow. The method described in the report for visualizing air flow depends upon the fact that the moisture in the air condenses as a fog when the temperature is reduced to the dew point, provided that there is a solid or liquid nucleus to start the condensation. In the McCook Field wind tunnel the temperature drop is brought about through expansion of the air during acceleration, due to a drop of pressure of 100 inches of water. The relative humidity of the atmosphere can be artificially raised if too low, and the necessary nucleus for condensation is provided by the model tested. Flow vortices become readily visible, and the report contains many photographs showing the air flow past an aerofoil under different conditions.



THE NEW GOODYEAR PONY BLIMP, WHICH IS EQUIPPED WITH A CABIN CAR ACCOMMODATING THREE PERSONS.

The Packard 500-600 Hp. Aircraft Engine

The Packard 1-A-2025 aircraft engine is the design of Col. Jesse G. Vincent, who was one of the creators of the Liberty motor, and is now vice president of engineering at the Detroit plant of the Packard Motor Car Co., where the engine was built. His experience with aviation during the war gave him opportunities for study of the actual performances not only of the Liberty engine but of the best engines produced in England, France, Italy and Germany. His study of the weaknesses and strong points of these various engines and his knowledge of American quantity production methods have been combined to produce the present motor.

In this motor Colonel Vincent completes a series of three engines which were designed to meet all normal aviation needs. This is the largest, and is intended for either high speed or for heavy load carrying. Its combination of light weight and high power gives it an exceedingly wide range.

This engine in the main follows along established lines of the Packard aero engines. It has twelve cylinders, set in blocks of six at an included angle of 60 deg. The cylinder bore is 5¾ in. and the stroke 6½ in., while the total piston displacement is 2025 cu. in., from which the engine takes its name of "Packard 2025."

The engine weighs only 1.94 lb. per hp., and with water, piping and radiator 2.275 lb. per horse-power, being thus the lightest in proportion to its power of any standard engine. The actual weight with propeller hub, carburetor, generator and ignition equipment is 1,118 lb. A properly designed nose radiator weighs about 130 lb., the water in it 52 lb., and the water in the cylinder jackets, circulating pumps and pipes 58 lb., giving a total weight for the power plant of 1356 lb.

Specifications

Detailed specifications are:—

Piston clearance 0.020 in. Three rings above piston pin and one below it. Piston pin of floating type.

Longitudinal center of gravity ⅝ in. behind the center line of the engine.

Valves:—Two inlet and two exhaust per cylinder, an innovation which will be discussed in detail later. All valve ports 2 in. in diameter. Exhaust valves lift ⅜ in. and inlet valves 7-16 in.

Compression ratio 20 per cent.

Ignition full advance is 45 deg. early and full retard 9 deg. late.

Inlet valves open 10 deg. after top center and close 45 deg. after bottom center; exhaust valves open 48 deg. after bottom center and close 8 deg. after top center.

Crankshaft is of seven bearing type, with bearings carefully proportioned to give uniform working life.

Connecting rods are of straddle type, carefully balanced and proportioned.

Pistons are aluminum die-cast, with floating piston pins. Center of piston head is supported and cooled by a pedestal resting on the piston pin.

Propeller hub is of quick-detachable type, designed with special care to prevent working loose or freezing on shaft. Crankcase is of box-section type, split along center line of the crankshaft, and with the main bearings carried between the halves. Long through-bolts which unite the two halves serve the purpose also of giving a perfectly rigid unit:

Cylinders are of individual steel type.

Camshaft and rocker-arm assembly is enclosed, with special devices to prevent leakage.

Lubrication is of full pressure feed type, operating with a dry sump.

Radiator, according to design, is of nose type, but the engine is equally adaptable to any other type of cooling system.

Ignition is of improved Delco type, in which the distributor heads remain stationary and the spark advance is obtained by advancing the drive shaft. Complete double ignition to two sets of spark plugs is provided and the engine will perform excellently on either.

Throughout the design of the engine the utmost pains were taken to insure accessibility of all working parts and ease of installation. As a result, the engine is believed to be the most accessible of any of its type yet built. The distributor heads, for example, are easily reached from either side of the fuselage, and the water pump is at the bottom of the rear end of the crankcase.

Carburetor

The most important new development is in the location of the carburetor, which has been placed at the bottom of the crankcase and outside it. This arrangement provides great accessibility, and saves considerably in the weight of tubing and feed pump since it gives gravity feed with a minimum of piping. Most important, it makes the engine entirely fireproof so far as the carburetor is concerned since all vents are outside of the cowling.

Another important innovation is the use of a single duplex carburetor instead of two, as has been the practice. This carburetor is of the double-venturi type with an improved altitude control, and is, of course, equipped with the Packard fuelizer, which insures perfect combustion even with very poor grades of gasolene and gives the aviator the great advantage of being able to start his engine when it is cold after a long dive.

"We considered it more or less of an experiment to attempt this use of a single duplex carburetor," says Col. Vincent of this layout, "because we had no data to show whether the arrangement would give us good distribution and maximum power. There were so many overwhelming arguments in favor of a single carburetor, however, that it was decided to make the attempt, and it is most gratifying to note that the results certainly justify the design.

"The data which the tests have given us in regard to power output, gasoline economy and inlet manifold depression show a very satisfactory result. I think it very doubtful whether two carburetors could have done better in these things. And in all others the advantages in favor of the single carburetor are great.

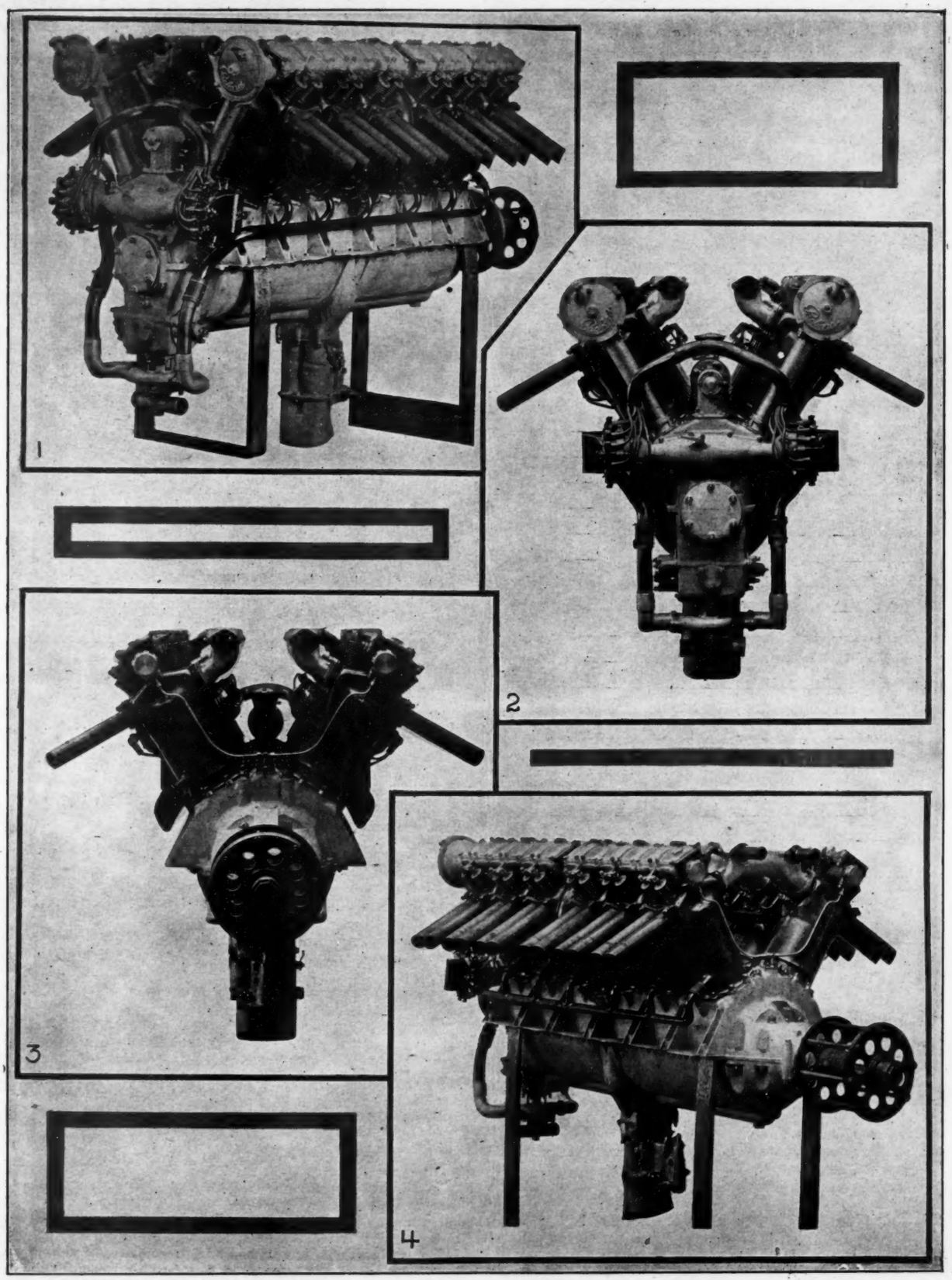
"There has always been a serious trouble in synchronizing the throttle control, as well as the altitude control, of two separate carburetors, and in this way alone the use of a single carburetor can be considered a distinct advance. It is also a great advance from the point of view of installation and maintenance because it permits gravity feed, eliminates piping and other weight, and particularly, because of its fireproof design. It is a change which certainly should commend itself at once to the airplane engine designer."

Valve Gear

The biggest mechanical advance has been made in the introduction of four valves and in the rocker-arm and camshaft mechanism. A double finger handles each pair of valves together and provides an even unit pressure on the rocker-arm bearings which shows in their perfect condition after long use. The enclosed type of assembly of this mechanism used was developed by Packard engineers under Col. Vincent's direction before the war and was contributed to the Liberty motor. It has now been further improved to insure better lubrication and greater tightness. A design which provides a bearing on either side of the rocker-arms, a device for sealing the openings at the outer ends of rocker-arm journals, and the small clearance which these make possible at this point have resulted in producing an assembly which in the matter of leakage of oil puts this engine distinctly ahead of its predecessors.

The individual cylinder, again of the type which was used in the Liberty motor, but with improvements, was also developed before the war in the Packard plant. It is now generally recognized as being among the best that have been designed because it has the best possible water circulation and therefore the best valve cooling, with the result that, as has been shown in the performance of the Liberty motors, valve trouble is practically eliminated.

The accuracy of the design and the perfect balance of the new engine was remarkably vindicated when it was put under test. It was put on the testing jacks exactly as it came from the assembly department and not a single change or adjustment of any kind was necessary except in the carburetor. After this had been set, the engine went through the entire test without adjustment of any kind and without developing any weakness or trouble. There was not a trace of fouling of



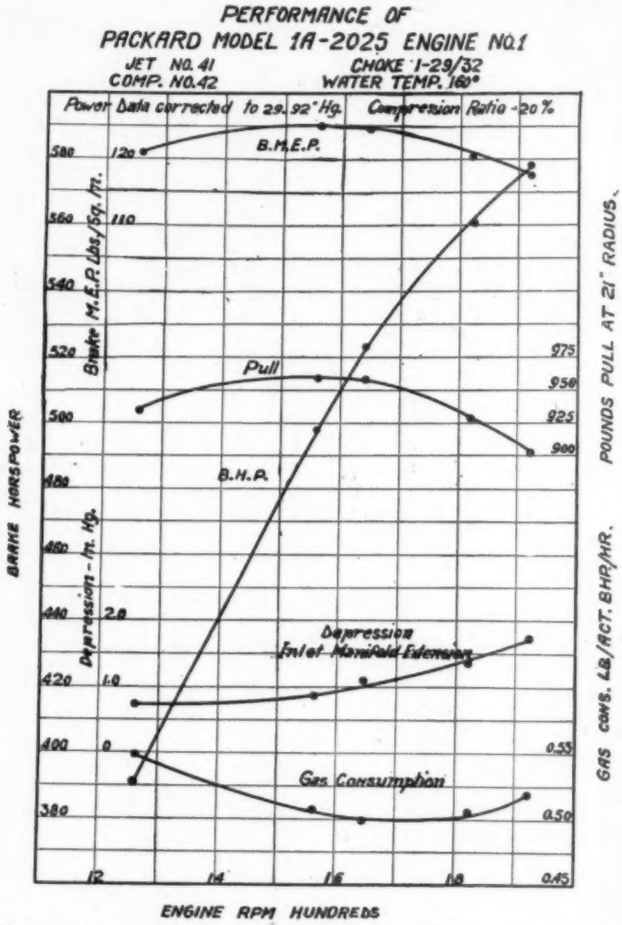
FOUR VIEWS OF THE 500-600 HP. PACKARD AIRCRAFT ENGINE —(1) THREE-QUARTER VIEW, MAGNETO END; (2) AND (3) MAGNETO AND PROPELLER END VIEWS; (4) THREE-QUARTER VIEW, PROPELLER END.

the spark plugs. The test sheet, published herewith, was made from the first engine of the type on its first run.

Power Output on Block Test

The engine, after it came from the assembly department, was run for 15 hr. on a lapping-in jack, being driven by an electric motor. It was then run under its own power for 20 hr. at about 500 r.p.m. The tests were then made, a 400 hp. Sprague dynamometer being used. The smoothness of the engine was remarkable, especially at the higher speeds above 1500 r.p.m. So far as could be judged on the dynamometer, the acceleration was smooth and fast. At 250 r.p.m. the engine idled very nicely.

The power curve shows that the engine developed 400 hp. at 1235 r.p.m., went to 500 hp. at 1570 r.p.m. and reached a maximum of 585 hp. at 1925 r.p.m. It was thought inadvisable



PERFORMANCE CHART OF THE 500-600 HP. PACKARD AIRCRAFT ENGINE

to push the tests beyond this point both because of the limitations of the testing apparatus, which was already heavily overloaded, and because this was the only engine of the type so far ready. But the power curve assures a development of 600 hp. at 2000 r.p.m.

When the carburetor was adjusted for maximum power output, the engine showed a gasoline economy of .5 and .52 lb. per hp./hr. But with adjustments to give a slightly smaller power, it proved possible to get an economy as low as .45 lb. Because of the risk of overheating the dynamometer it was thought unwise to make a prolonged run at high speed, but the oil consumption indicated is from .01 to .03 lb. per hp./hr.

The engine was completely disassembled and a very careful examination of all the working parts was made after the tests had been concluded. All the parts were found to be in first class condition throughout. The piston clearances had been ample, as it was found that the cylinders showed evidences of perfect lubrication. The rocker-arm journals were in excellent condition and the camshaft housing showed no evidence of galling at the bearings, undoubtedly due to the use of the bearing on both sides of the rocker-arm.

These preliminary tests were so satisfactory that when the motor was delivered at the aviation field, the engineers there decided that further ground tests were unnecessary although it had been planned to make them. The work of installing the engine in a high speed airplane, just completed, was begun at once, and flying tests will probably be under way before this article is printed.

Col. Vincent's wide experience and high reputation enable him to speak with authority even concerning an engine of his own design, in spite of his natural interest in it. He is greatly pleased with the performanc of this engine and predicts a wide use for it.

"The tests so far made fully justify the expectation of great speed from this motor," he said. "However, it is not primarily designed for racing, but for a wide and varied range of duties where high power is required or where high reserve power is desirable. The power curve indicates that this engine can be used in many different types of planes, and its comparative lightness and its smoothness at high speeds contribute greatly to its usefulness. It will have many advantages over any other type of engine with which I am familiar for all duties which require great power. Its flexibility makes it available for either heavy loading or high speed.

"For instance, this motor will be most suitable for the type of plane which we used in the war for night bombing, and which in commercial use would carry several passengers or freight. Such a plane would be a slow-moving machine and would need 400 to 425 hp. This engine will develop that power at around 1275 to 1350 r.p.m., and at this speed a very great propeller efficiency can be secured and the life of the engine will be greatly prolonged. Under such conditions I believe this engine will have a very long life, and it ought to give around 250 hr. flying without needing overhaul of any kind.

"The engine will be equally useful for the faster plane such as was used for day-bombing, or as will be used for mails with the development of the aerial postal service. The 475 hp. or more needed for this would be developed at about 1500 r.p.m. and there would still be a reserve power of some 125 hp. for use in case of emergencies, which is enough to meet almost any conditions.

"For speed the engine has its 600 hp. to give at 2000 r.p.m. It also has great endurance and reliability, as the tests have shown, so that there need be little fear of failure of performance. Its lightness makes it possible to mount it in a light low resistance plane, and it is more than safe to assume that some startling results in the way of high speed can be obtained.

"The greatest value of this engine, of course, will be in the commercial field, since it is toward that field that America must look for its future in aeronautical work. This is not and never has been a military nation, and we can be quite certain that Congress will never provide for the military air services the money which would permit the proper development of aeronautics. Yet this country will never be safe until we are able to dominate the air above it in case of emergency.

"This development can only come from the commercial field, and to insure it, commercial aeronautics must be placed on a financially sound business basis. Efficient and economical engines like this, which will make commercial aeronautics profitable, are therefore important factors in bringing about this necessary result."

Farman Goliath in 24-Hr. Flight

A Farman Goliath, piloted by Lieutenants Bossoutrot and Bernard, on June 4 broke the world's duration record by remaining in the air without landing 24 hr. 19 min. 7 sec. and covering a distance of 1,915.2 km. (1,196 miles).

The Goliath also established what are claimed to be records for 1,000 and 1,500 km., by covering the former distance in 11 hr. 29 min. 56 sec., and the latter in 16 hr. 42 min. 8 sec.

The former official world's duration record was established on June 28, 1914, by W. Landmann, who flew for 21 hr. 48 min. 45 sec.

Aeronautic Instruments

By Mayo D. Hersey

(Concluded from our last issue)

Design, Development, and Production

The design of aeronautic instruments is at present almost wholly on a cut-and-try basis. The Bureau of Standards has made some progress, however, in placing instrument design on a rational basis. Consideration has been given to such general problems as: the stiffness of elastic systems where two bodies such as a spring and diaphragm are coupled together; the effects of temperature and elastic lag on coupled systems; bimetallic bars for temperature compensation; the balance of moving parts to resist angular acceleration and vibration; the securing of a uniform scale by suitable design of transmision mechanism; and the treatment of aerodynamic problems and the general action of damping fluids by the method of dimensions described before this Society by Dr. Buckingham at the Buffalo meeting in 1915 in his paper on Model Experiments.

Experimental development has to follow the preliminary design of an instrument before it can be put into quantity production. It is here that the physical laboratory, in immediate conjunction with an instrument shop suitably equipped with watchmaker's tools in addition to the ordinary machine tools, plays an essential part. Among the recent development projects of the Aeronautic Instruments Section at the Bureau of Standards may be mentioned the following several of which were undertaken at the request of the Air Service or the National Advisory Committee for Aeronautics:

(a) The conversion of barographs from a low-altitude to a high-altitude range by the addition of a suitable external spring, together with the development of recording processes to eliminate the use of ink.

(b) The conversion of altimeters from an altitude scale to a pressure scale by the modification of the mechanism and engraving of special dials, so as to adapt them for aircraft performance testing. In connection with this work improvements were also made in the method of mounting the main spring of commercial altimeters so as to diminish the observed differences between readings with increasing and decreasing altitudes, or hysteresis as it is commonly called.

(c) The development of a precision altimeter with a large dial giving a ¼-in. movement of the pointer for each 100 ft. of altitude. In order to justify such high precision of reading, that is, such high sensitivity or openness of scale, a special design had to be made for the elastic system to diminish elastic lag. This was accomplished by making the steel main spring so many times stiffer than the diaphragm that the resultant action of the instrument is practically independent of the quality of the material in the diaphragm.

(d) The development of a direct-reading, rate-of-climb indicator based on the capillary-tube-leak principle, but in which the use of a liquid has been entirely dispensed with through the use of sensitive diaphragms.

(e) Development of a reduced-scale working model of a proposed gyro-stabilizer on the long-period pendulum principle, possessing mechanical features of extreme simplicity.

(f) The application of the moving picture camera, by means of an automatic timing mechanism, for the purpose of securing a record of instrument readings during the performance test of an aircraft in flight. The whole outfit, instruments, illumination, camera and timing-system, is self-contained and forms a unit which takes the place of the human observer in the airplane.

(g) A working model of a type of dynamical ground speed indicator which would become available if there existed a suitable gyro-stabilizer to hold it horizontal. This model consists of a large steel ball free to roll back and forth in a glass tube filled with a viscuous liquid. It can be shown mathematically that if the fluid resistance is directly proportional to the speed of the ball through the tube, while the tube is held in a horizontal fore-and-aft position, then the displacement of the ball at any instant from its initial position in the tube is directly proportional to the absolute ground speed of the aircraft.

The development work on any given model of an instrument must be dropped and the design rigidly fixed before quantity production can be efficiently carried on. In this country the quality of products made in quantity has to be artificially held up to standard by means of specifications and inspection. This situation is not so commonly met with abroad, especially in France, where every individual involved, from the mechanic in the shop up to the head of the concern, takes a professional artistic pride in the quality of his output. This difference is not the fault of the American manufacturer, and there are some advantages in our system, yet the fact remains that in Europe, instrument production has been successfully carried on without specifications. This spectacle of successful instruments formed one of the most astonishing impressions which the writer gathered from his trip to Europe during the war.

II. Testing of Instruments

The testing of any aeronautic instrument consists in general of a direct comparison with some suitable standard, the instrument being operated from point to point over its full scale; the whole procedure should then be repeated under different temperatures or other important conditions varying in flight. The most important of these conditions are:

(a) Extreme low temperatures
(b) Change in pressure or density of air
(c) Acceleration and inclination
(d) Vibration
(e) Time elapsed during the flight.

A typical installation of testing apparatus, in this instance for the testing of tachometers, is shown in Fig. 4. The results of such a test are ordinarily given out in the form of tables or curves showing the correction of the instrument from point to point of its scale. By the correction is meant the amount that has to be added algebraically to the reading of the instrument in order to give the true value of the quantity measured. Typical correction plots or curves of this sort are seen in the first two charts shown on Fig. 5.

There are various degrees of refinement possible in the testing procedure, and instrument tests may be classified as follows:

(a) Factory inspection tests
(b) Short test for service instruments
(c) The Bureau of Standards general test
(d) More thorough tests on sample instruments
(e) Special tests on experimental instruments
(f) Reproduction of the flight-history.

Factory inspection tests can be reduced to a comparatively simple routine after the first few instruments of each pattern have been inspected. In some cases it is permissible to determine simply the corrections at one or two points on the scale, and to omit some parts of the test entirely, except on a prescribed number of samples selected at random from each lot. The purpose of such tests is to control the quality of the output so as to maintain the standard of performance agreed upon in the specifications.

The *short test for service instruments* is an attempt to secure, in a minimum time, such data regarding the maximum calibration correction or temperature effect as may be needed for actual reference in connection with the installation or use of instruments on aircraft.

The *Bureau of Standards general test* is the one which is furnished on instruments submitted to the Bureau without special instructions. It is a comprehensive standard form of test affording a complete calibration curve together with, at least, numerical values for the more common errors due to temperature and other well known conditions. The data from this general test are sufficient for calculating the probable performance of the instrument under any given set of flight conditions. However, when those conditions are actually known, more exact results can be obtained by carrying out the flight-history tests described under *(f)* below.

* Abstract of a paper read before the American Society of Mechanical Engineers.

The Bureau makes *more thorough tests on sample instruments* of new type whose mechanism is not familiar. Such additional observations usually include some form of accelerated life-test, such as a five-day run to determine the endurance of the instrument under vibration. For this purpose adjustable vibrating stands have been made which reproduce the condition of vibration of an airplane instrument board. The steadiness of the pointer and the accuracy of the instrument with and without vibration are also observed in connection with such a test.

The *special tests on experimental instruments*, depend, of course, on the nature of the work for which the instrument is to be used, and on the flight conditions which will prevail. The readings in such a test may have to be taken to a higher degree of precision than usual, and may require specially refined standards.

For instruments such as aneroid barometers, which involve serious errors due to elastic lag or temperature lag, there can be no more reliable method of determining the corrections necessary for the interpretation of the readings than to make a *flight-history* test by actually reproducing in the laboratory the identical variation of pressure, temperature, etc., which was experienced from time to time during the flight. This is particularly important in connection with the use of barographs for competitive altitude flights. It is now well known that barographs subject to any appreciable amount of elastic lag will read a higher altitude the greater the time elapsed during the flight.

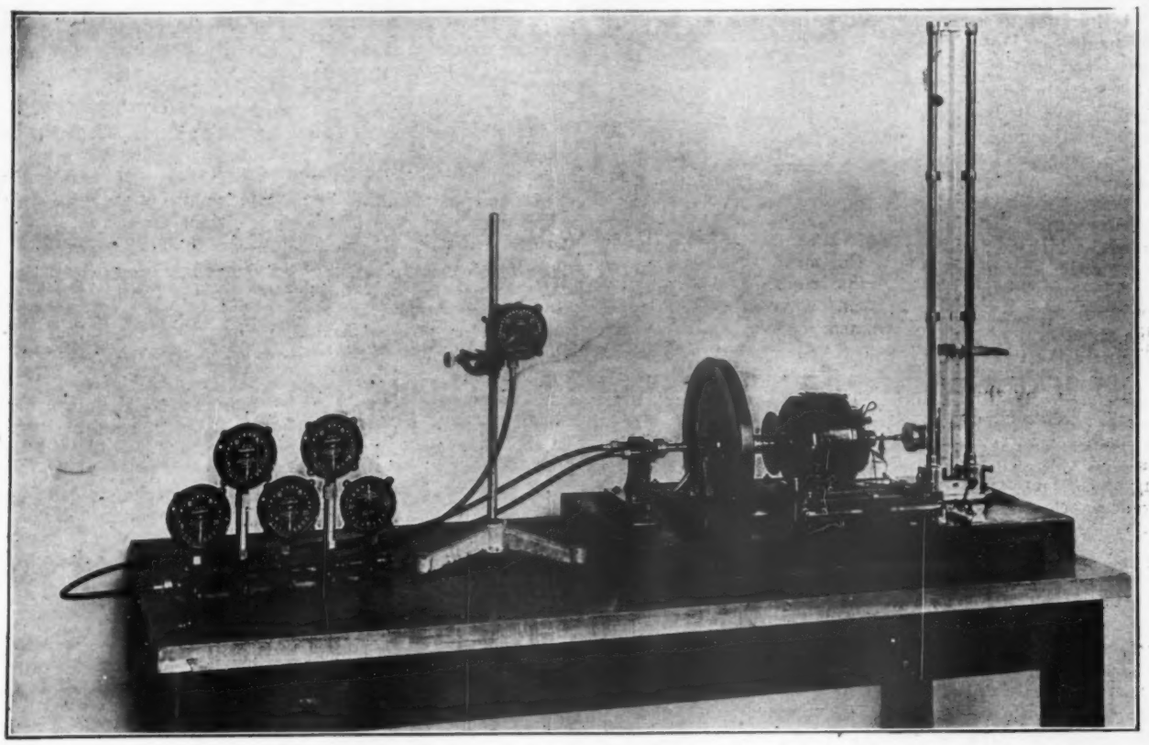


FIG. 4. TESTING OUTFIT FOR AIRPLANE TACHOMETERS

It is a short step from some of these more complete testing methods to the general subject of the experimental investigation of sources of error on instruments. Such investigations have formed one of the most interesting features of the work of the Bureau of Standards and are illustrated by Figs. 5 and 6, which are based on experiments with high-grade aneroids.

In Fig. 5 the first chart *(a)* shows the ordinary calibration of an aneroid changing the pressure at the rate of an inch of mercury in five minutes. (At sea level one inch of mercury corresponds to about one thousand feet of altitude. At twenty thousand feet one inch corresponds to about two thousand feet of altitude.) The calibration curve would be distinctly different at some different speed, due to elastic lag in the corrugated metal vacuum boxes. For the same reason, as shown in the second chart *(b)*, the discrepancy between the readings going up and coming down is much greater when the aneroid is held at the maximum altitude for a considerable time interval. This drift, or change of reading at constant pressure, is shown in the third chart *(c)* as a function of the time elapsed. Such curves may be taken as a criterion of the elastic quality of the material in the instrument; and several hundred such have been determined in the course of the Bureau's investigations. The curves in Fig. 6-A show the increase in the width of the hysteresis loops with rise of temperature, and it also shows the decrease in the sensitivity of the movement when an instrument is chilled. This last effect is largely due to the change of elasticity with temperature, and cannot be fully compensated for by means of the ordinary bimetallic lever. The remaining curves, Fig. 6-B, show, on the other hand, what can be done in the way of temperature compensation. One represents a typical uncompensated aneroid. The graph shows the change of reading with temperature at a constant pressure corresponding to sea level conditions. Another shows a partial degree of compensation obtained by admitting air to the vacuum box. The third shows satisfactory compensation by means of a bimetallic bar so far as sea-level observations are concerned; but this same aneroid may have a serious temperature error when the movement has shifted into the new position which it will occupy at twenty thousand feet.

Still further characteristics of aneroid barometers have been studied at the Bureau in addition to those shown in Figs. 5 and 6 and similar investigations have been extended to all of the other aeronautic instruments.

Use of Instruments

Many practical airplane pilots disclaim the use of instruments, and certainly it is desirable that the aviator should be trained to become just as independent of any mechanical aid as possible. Yet it would hardly do to equip planes without all of the usual service instruments, for those instruments which one pilot thinks he can dispense with are precisely the ones the next pilot would insist upon having. And if the instruments are to be installed at all, even though they may not be read frequently, it is necessary for them to be reliable,

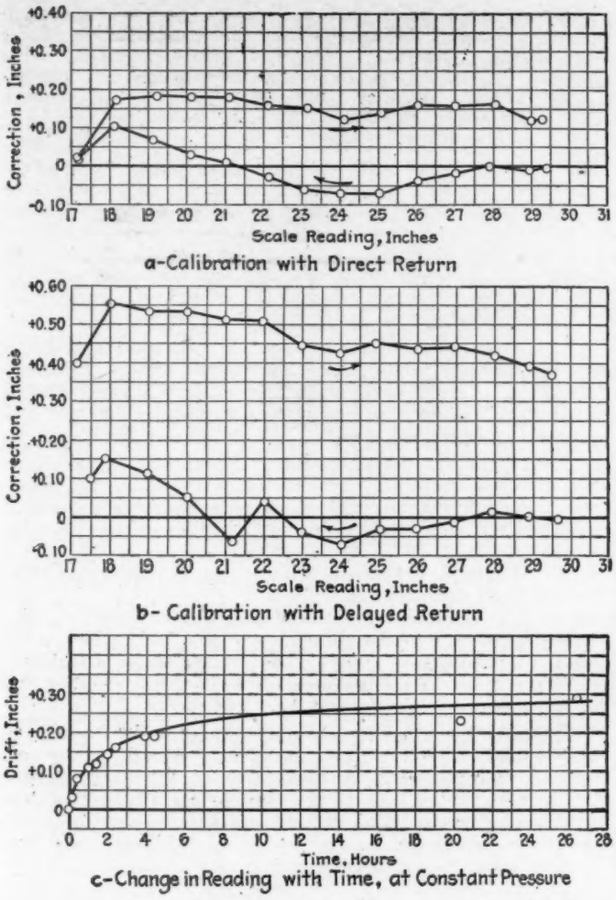


FIG. 5. EFFECT OF ELASTIC LAG ON ALTIMETERS

and so the whole subject has to be studied and put on a solid scientific foundation.

Some of the times when airplane instruments are really of the most importance are the following:

(a) For various military and naval operations such as bomb dropping.

(b) Long distance navigation

(c) Flying at night and in clouds

(d) Preparing to land on a perfectly smooth body of water where the height is deceptive

(e) Flying in formation with instructions to hold to a prescribed air speed and altitude

(f) Photographic and survey work.

The need for instruments is still more evident in airship work. Here it is necessary to control the position of the ship, especially near the ground, with comparatively greater precision; nor is it possible for the pilot to act so quickly in response to his unaided senses as it might be in an airplane.

The following precautions may be suggested for getting the best results in the practical use of service instruments:

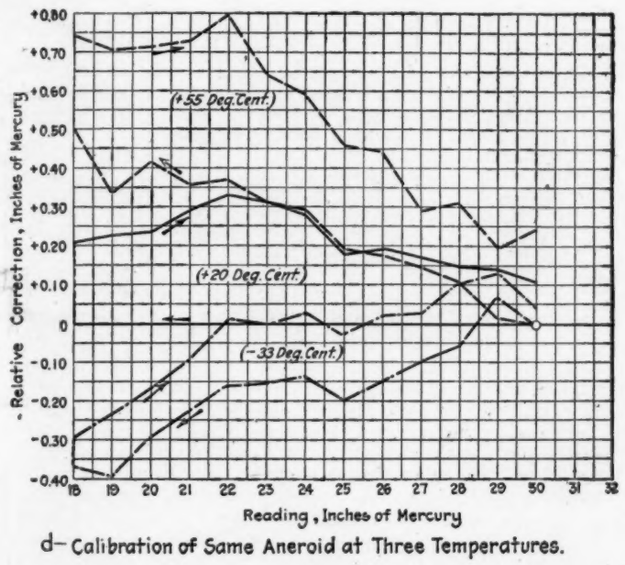
(a) Select for installation in the first place only those instruments which can be certified by the Bureau of Standards as suitable for the intended use. Such approval will ordinarily depend more on the performance of each individual instrument as evidenced by tests, than it will upon the make or design.

(b) In any event see that the instrument is tested immediately prior to installation to avoid the occurrence of large errors due to secular changes or to mechanical injury. If the errors thus found are not considered negligible, a small correction card can be furnished with each instrument.

(c) Where accuracy is required in flight observations the aviator must refer to these corrections. He also must remember where appreciable lag errors, are stated to exist, whether due to elastic lag or temperature lag or other causes, that some time will be required for the instrument to completely respond to any given change, and that the results will be different with increasing and decreasing scale readings. Instruments are usually adjusted to be correct for increasing readings. If such instruments show an appreciable lag during the test, then in service they will tend to read too high when the pointer is falling.

(d) At least once in six months it is desirable that instruments should be overhauled, during which time they may perhaps be replaced by a reserve supply of fresh instruments properly tested and adjusted. Instruments which are visibly damaged or out of adjustment may be sent to some central station such as the Bureau of Standards for salvaging. Even if they are not visibly out of adjustment near the zero point of the scale, they may reveal surprising errors further up on the scale if properly tested, and this should be done periodically.

The problem of salvaging has been studied by the Bureau of Standards both in connection with the writer's official visit to the various aerodromes and salvage stations abroad during the war and more recently in connection with the salvaging of instruments for the Air Mail Service. The statistical results of such work are of the greatest value as a basis for future improvements in instrument construction, and should provide the raw material for important scientific study. The actual salvage proposition consists of dismantling a certain number of damaged instruments and putting them together again so as to form a smaller number of good instruments. The study of expedients for readjusting the mechanism forms an integral part of such work. This can only be done in the testing laboratory. Now unless it is early discarded in favor of some new type, it will be the destiny of every instrument that is manufactured to come back for salvage or readjustment eventually. Hence the facility with


Relative Correction, Inches of Mercury
(+55 Deg. Cent.)
(+20 Deg. Cent.)
(-33 Deg. Cent.)
Reading, Inches of Mercury
d- Calibration of Same Aneroid at Three Temperatures.

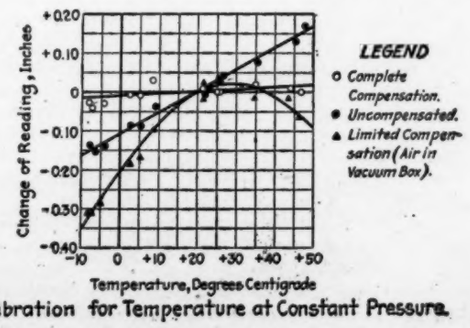


FIG. 6. EFFECT OF TEMPERATURE ON ALTIMETERS

which such readjustment can be made, is a criterion not to be overlooked in connection with the purchasing of instruments.

Such readjustments have to be made with due regard to securing a uniform scale and a satisfactory degree of temperature compensation. In some cases it is simpler to prepare new dials graduated empirically to fit the altered performance of the movement.

So much for service instruments. The use of experimental instruments, on the other hand, is more obvious, since they do not form a part of the permanent equipment and are called for only when actually needed for special observations. The procedure for such observations is too elaborate to go into here except by way of illustration. Consider, for example, the use of the barograph for high-altitude determinations. The following is an outline of the procedure for determining

(a) The most probable altitude

(b) The official altitude for competitive purposes in accordance with the rules of the International Aeronautic Federation.

Whichever method of computation is to be used, only such barographs should be selected for the flight as have passed, or could pass, the performance requirements for a Bureau of Standards certificate. Particular attention should be given to the reliability of the clockwork, which is preferably such as to give a rapid movement to the drum: for example, one revolution per hour. The pressure scale should also be as open as possible, which means an extra tall drum. The whole movement must be rigid and strong. The pen must be adjusted without undue friction, but so that the ink will flow freely and trace a delicate but definite line. Charts graduated in pressure units are convenient, and must be of good quality.

Unless the barograph is practically free from temperature errors, a standardized thermometer should be attached to the barograph case and several readings taken during the ascent. And unless the barograph is also free from temperature lag, such a thermometer should be placed inside the case, with its bulb close to the vacuum boxes.

For the *most probable altitude* determination, two barographs may be taken, and the results averaged after all corrections have been applied. In this method, the pen may be adjusted before leaving the ground to read the true pressure as determined by a standardized mercurial barometer at the field. Readings of a good strut thermometer or thermograph should be obtained at least every 2000 ft. for the determination of atmospheric temperature distribution.

To determine the instrument correction at the starting point and at the ceiling by laboratory test after the flight, the flight-history method of testing should be used; that is the barographs should be put in a receptacle within which both temperature and pressure can be made to follow sensibly the same curves with regard to time that were experienced during th flight. By comparison with a standardized and fully corrected mercurial barometer, the true pressure corresponding to the base and ceiling readings can thus be found.

The altitudes corresponding to these two pressures are next to be found on the 50 deg. fahr. altitude-pressure table issued by the Bureau of Standards. By subtracting the base altitude from the ceiling altitude thus found, a figure results which represents the relative altitude above the ground on the assumption of an isothermal atmosphere at 50 deg. fahr. This fictitious altitude is then multiplied by a correction factor given in the Bureau of Standards tables, to correct the result for the true mean temperature of the air column. This mean temperature has to be computed in the proper manner. The derivation of the most general altitude formula from fundamental physical principles shows that the particular kind of a mean temperature which is needed here, is the arithmetic mean of a series of temperatures equally spaced with regard to the logarithm of the pressure; or what amounts to the same thing, equally spaced with regard to the isothermal 50 deg. fahr. altitude. It would not be correct to take the mean temperature for equally spaced intervals of pressure. To the altitude thus obtained, there has to be added, finally, the official altitude of the base station above sea level.

For the determination of *competitive altitudes* by the International rule, it is only necessary to carry up one barograph, and no strut thermometer is required.

Purely instrumental corrections may be obtained as before but the method of computation is different. This method of computation is very much simpler than the other, in that it does not require any record of the atmospheric temperature during the flight. It consists of a direct substitution of the true ceiling pressure into the International formula. This formula is a definite relation between pressure and altitude involving only numerical constants. It was based upon sounding balloon observations taken in Europe.

In the use of this method, it is understood that the barograph pen should be adjusted, at the start of the flight, to read whatever pressure corresponds to the known altitude of the station by reference to the International formula.

Conclusions

In concluding this paper, a recapitulation may well be made of some of the outstanding problems of instrument development, the solution of which is much to be desired:

(a) A satisfactory gasolene depth gage is needed.

(b) Barographs and other recording instruments of better quality than any now existing are needed. Better clockwork, and a much more open scale, and more complete freedom from errors due to friction, temperature, elastic lag, and lack of balance are desirable.

(c) A wholly satisfactory form of compass for airplanes is not as yet available. Besides the northerly turning error, so-called, to which all single-pivot compasses are necessarily subject, there are troubles due to the action of the damping fluid.

(d) Air-speed indicators suitable for the low speeds of airship flight are required.

(e) A gyro-stabilizer is needed, different from existing types in that it must be able to stabilize a body which is not rigid, but contains a freely moving mass. Such a stabilizer is necessary before the full possibilities of any dynamical type of ground-speed indicator can be realized.

The material in this paper is of course not due to any one individual, but is based upon the work of the entire Aeronautic Instruments Section of the Bureau of Standards. Later, the detailed official reports prepared by the various members of the staff concerned, should be available through the publications of the Bureau and the National Advisory Committee for Aeronautics.

CONSTRUCTION OF THE CABIN OF THE VICKERS COMMERCIAL AIRPLANE

Wide World Photos

The Efficiency of Airplane Struts

By Wallace F. Wiley

In airplane design it is advantageous to have some method of comparing the power absorbed by struts of various shapes and materials, so that, for the velocity under consideration, the most efficient strut can be used. This is based on the assumption that, at the given velocity, the most efficient strut of a series, all of which are of the same length and which have the same final strength, is the one which absorbs the least power. It is the purpose of this article, therefore, to establish the general equation for the power absorbed by a strut of any material, section, length and strength at any velocity, and to show how this equation can be applied.

The following symbols will be used:

a = area of strut section in sq. in.
b = breadth of section normal to wind in inches
l = length of strut in inches
$n = \frac{a}{b^2}$
$m = \frac{k^2}{b^2}$
k = radius of gyration of section
P = total power absorbed by strut
V = velocity in m.p.h.
ρ/g = density of air/acceleration of gravity = .00238
C = absolute resistance coefficient of section
E = modulus of elasticity of material
w = weight of material in lb./cu. in.
r = lift/drag ratio of plane
F = final strength strut in lb.
A = projected area of strut normal to wind in sq. in = $1 \times b$

The power absorbed by a strut consists of two parts, one of which we may call the weight power, and the other the resistance power. The weight power can be considered as that power required to force through the air at the given velocity a lifting surface just large enough to support the weight of the strut. The resistance power is the power required to force the strut itself through the air. The total power absorbed, then, is the sum of the two powers.

$$\text{The weight power} = \frac{wlaV}{375r}$$

$$\text{The resistance power} = \frac{CAV^3\rho/g}{375 \times 144}$$

$$\text{Then } P = \frac{wlaV}{375\,r} + \frac{CAV^3\rho/g}{375 \times 144} \qquad \ldots\ldots\ldots\ldots (1)$$

$$\text{But } \frac{F}{a} = \frac{8.72\,E}{(l/k)^2} \text{ or } k^2 = \frac{l^2 F}{8.72\,Ea}$$

Now $a = nb^2$

And $k^2 = mb^2$

$$\text{Therefore } mb^2 = \frac{l^2 F}{8.72\,Enb^2}$$

$$\text{Or } \qquad b = \sqrt{\frac{l^2F}{8.72\,Emn}} \qquad \ldots\ldots\ldots\ldots (2)$$

$$\text{And } \qquad a = n\sqrt{\frac{l^2F}{8.72\,Emn}} \qquad \ldots\ldots\ldots\ldots (3)$$

Then from equations (1), (2) and (3)

$$P = \frac{wlnV}{375\,r}\sqrt{\frac{l^2F}{8.72\,Emn}} + \frac{ClV^3\rho/g}{375 \times 144}\sqrt{\frac{l^2F}{8.72\,Emn}}$$

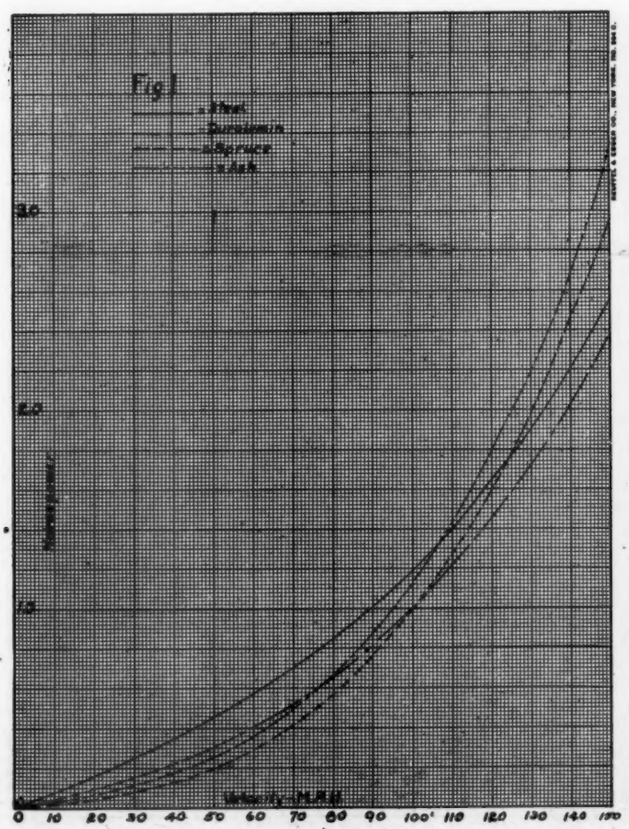


FIG. 1.

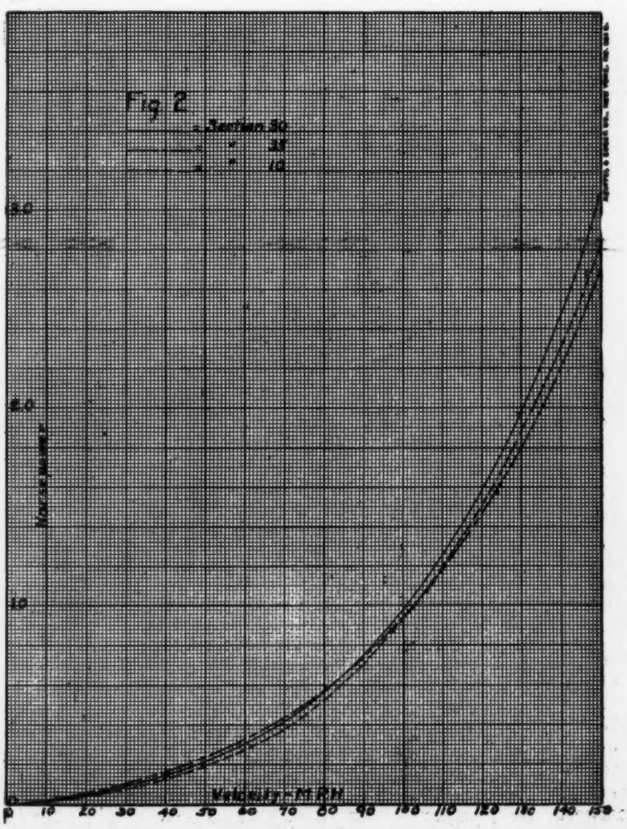


FIG. 2.

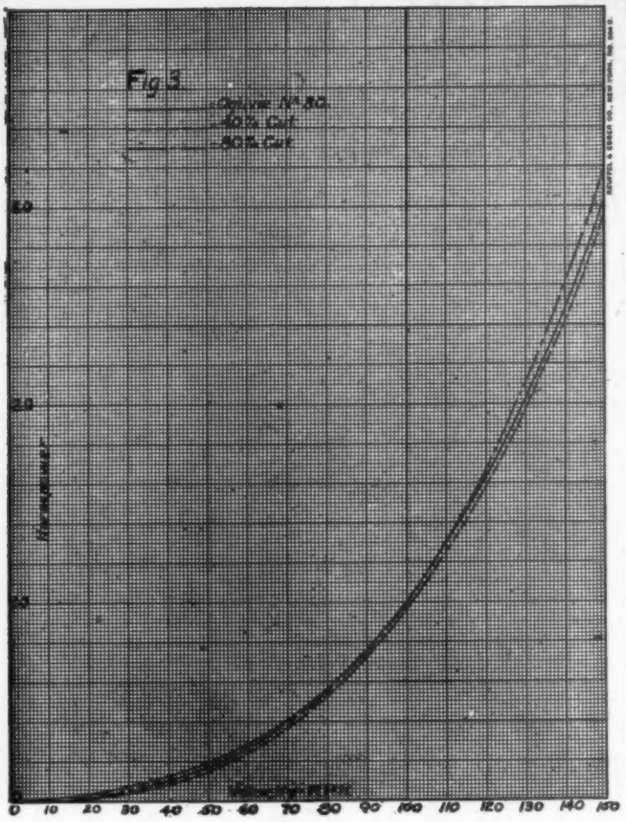


FIG. 3.

$$P = \frac{lV}{375}\sqrt[4]{\frac{l^2F}{8.72\,Emn}}\left(\frac{wn}{r}\sqrt[4]{\frac{l^2F}{8.72\,Emn}}+\frac{CV^2\rho/g}{144}\right)\ldots.(4)$$

which is the general equation for the power absorbed by any given strut.

The figures show the application of formula 4. The lift/drag ratio for the theoretical supporting plane is taken as 6.

Fig. 1 represents the power absorbed by struts of spruce, ash, steel and duralumin of strut section Ogilvie No. 30, length 72 in. and final strength 1000 lb. It will be noted that for this particular strut form the duralumin strut, due to its greater weight, is less efficient than the spruce strut at velocities lower than 100 m.p.h., but, on account of its higher modulus of elasticity and consequently smaller projected area, is more efficient at greater velocities. In Fig. 2, the graphs plotted are for Ogilvie sections 10, 30 and 35, material spruce, length 72 in. and final strength 1000 lb. In Fig. 2, graphs are plotted for section 30 with four other sections the same as 30 externally, but with material removed from the center to a depth of 40 per cent and 80 per cent respectively of the external breadth of the section. In these cases, the total power up to about 90 m.p.h. decreases with the amount of material removed, but increases at higher velocities, due to the increased external breadth.

The Fairchild Automatic Camera

The new Fairchild Automatic Aerial Camera, Model A, embodies the latest and most approved ideas in the line of an automatic mapping camera. The magazines, which are detachable, have a capacity of 75 ft. of 24 cm. film (9-7/16 in.) giving a total of 108 exposures. Each magazine contains a device for equally spacing the exposures upon the film, that is the margin between the pictures is kept uniform; in this manner the waste of film is kept at a minimum. The connection between the magazine and the camera is made by a self-centering clutch, which enables the operator to set the magazine in place in the camera without the necessity of previously locating the connections. This makes for speed in changing magazines.

The shutter is of the well-known Fairchild High Efficiency Between-the-Lens type having an *actual* speed of 1/40 to 1/150 sec.

The mechanism for operating the camera is located in the top of the cone, easily accessible. The drive is by motor. This motor can be fastened direct to the camera and connected, as in the Government types, by a flexible shaft. The power is furnished by a 12 volt storage battery.

This camera has an attachment whereby, if the power should fail, it can be operated by hand at the same speed and power, thus keeping the interval between exposures the same as though driven automatically.

The cones or snouts are of one piece of aluminum spun into shape, there being no seams nor projections to hinder placing it in its mount.

The intervals between exposures are controlled by a separate unit, which can be placed anywhere in the plane. This control can be set at any interval and once set is positive. It embodies not only a device for regulating the intervals between exposures, but also a switch for stopping, starting and for throwing the camera over into hand control, a pilot light, which flashes when the shutter releases, a counter to indicate the number of exposures and a button for use in taking individual pictures.

The entire camera has been designed to do away with all intricate mechanisms that have been so common to automatic cameras, to give, when operated automatically, a roll of perfect overlapping pictures, to furnish a means of taking one roll after another without breaks in the train of exposures and, finally, to do away with all the distortion that has heretofore manifested itself in these cameras.

The standard focal length is 12 in. and a choice of Cooke Aviar, Bausch & Lomb Tessar, Aldis, Berthiot or Carl Zeiss f. 4.5 lenses is given.

NEW FAIRCHILD AERIAL CAMERA, 18 x 24 CM.

Airship Suspensions

By Ralph H. Upson

Chief Aeronautical Engineer, Goodyear Tire and Rubber Co.

As a matter of definition the word "suspension" is used to designate the means by which the car of a non-rigid airship is attached to the envelope. This comprises the cables and any incidental cordage, together with their attachments at each end.

The earliest form of suspension was by means of a net which passed over the entire envelope. This is still commonly used on free balloons on account of its simplicity, convenience, and the fact that the resistance in this case is hardly an item to be considered.

Before the war nets had become largely obsolete on airships, but the best suspensions were still very complicated. The general system as then used consisted of a multiplicity of cables, each one further sub-divided several times, terminating at the envelope in hundreds of small cords which were usually attached to a heavy band or loop passing horizontally around the balloon. This type of suspension was retained on kite or observation balloons up to the very end of the war. The purpose, of course, was the obvious one of distributing the stresses as uniformly as possible over the surface of the fabric; but the system was complicated, heavy and subject to frequent breakages, due to the large number of small cords and attachments, and most serious of all, the resistance was found to be literally enormous. Tests indicated that these airships commonly had a total resistance over four times what would be anticipated from the envelope alone. A large part of this extra resistance was clearly due to the suspension.

It is impossible to say who first appreciated the great

GOODYEAR FINGER PATCH

importance of cutting down this parasite resistance. It was a natural development that took place nearly everywhere as aerodynamic knowledge and the results of wind tunnel experiments became known. In this country we were faced almost at the outset of our airship construction program with the practical necessity of improving the cordage and band type of suspension which was standard at that time.

A thorough study of the subject was made, new ideas of all kinds collected and tested and the result was the so-called finger patch, which in all essentials has remained the same ever since. The principle behind this patch is extremely simple. It is only a means of accomplishing, in and on the fabric itself, what was previously accomplished outside. In other words, instead of distributing the stress to the fabric by means of a multiplicity of divided and subdivided cords, we lead the stress directly to the envelope in more concentrated form and distributed it on the surface of the fabric itself.

As usual, however, the fundamental idea was but a small part of the larger problem of actually designing a patch that would accomplish the desired purpose. The ideal, of course, is to have a patch which develops practically the full strength of the fabric, and which is just strong enough to take its own fair share of the load. This has been accomplished by proper adjustment of such variables as length and number of fingers, strength and distribution of strength along each finger, proper stretch at different points, the angle between fingers, and local reinforcements.

The actual dimensions and strength of any particular series of patches must be designed to suit the fabric on which it is mounted. The design must also take into account the way the fabric is used; in other words, the relative circumferential and longitudinal stresses which occur in the balloon under different conditions. The patch here shown was designed for a particular balloon, and would not necessarily be ideal for other types and sizes. The same principle of construction, however, would still hold.

Since the introduction of the finger patch other improvements in the suspension have been made which have still further increased its efficiency. Rope has been entirely eliminated, steel cable being now used all the way to the envelope. Various connections have been improved, the upper bridle shortened and in many cases done away with entirely, and now the application of rubber streamline to the cables themselves promises to reduce the resistance still further. At almost every step the weight, although less important, has also been rpduced. The strength and durability have been increased rather than decreased. Generally the patches are designed, when mounted on the proper fabric, to hold four times their normal flying load.

The Stout Batwing Monoplane

The Stout Batwing monoplane is a giant wing in which are accommodated machinery, trussing, etc. The engines are set into the leading edge, the passengers are enclosed between the surfaces of the wing section, and every part that is exposed to the air is designed to lift.

The central part of the wing is thick and of long chord, the tips thin and narrow. In fact, the ship follows more closely the butter-fly than the bird in its plan view, and gives more surface within smaller dimensions.

An experimental machine was first flown at Dayton in the spring of 1918 and this machine used for research and development work toward later models. At present several commercial types of ships are being designed or are on the way, and some enormous planes intended for military use.

The thick main wing is not only framed up entirely of veneer, but the surface as well is formed of this extremely tough and water-proof material. The veneer on the surface is three-ply and only 1/20 in. thick. The wings are strong enough however so that one can walk all over them as a sidewalk.

The radiators in this ship pull into the wings when high altitudes are reached, and the heat from them is utilized to warm the passengers and pilot. In the large type even the landing gear is pulled into the wing when the ship is off the ground, increasing its speed by about 10 m.p.h.

A new ship of this type being laid down has a span of 100 ft., and a wing depth of 7 ft. at the center. It has within it a compartment for mail, bombs, or passengers as the case may be, this cabin being 30 ft. long, 6 ft. high and 8 ft. wide.

The Advisory Committee for Aeronautics

The report of the Advisory Committee for Aeronautics (British) for 1918-19 which, although it is dated last August, has only just been issued, indicates how greatly the activities of the Committee have had to be expanded in order to cope with the many demands from the R.A.F. and the industry. The Committee has now reverted to its former practice of indicating some of the more important work carried out during the period under review, and the present report indicates not only the progress which has been made in aerodynamical research, but also in the manipulation of aircraft. It is pointed out, for instance, that as a result of the investigations carried out at the Royal Aircraft Establishment and the N.P.L., there is now practically no aspect of the complicated motion of spinning which cannot be explained and made the subject of calculation.

Experimental work in aerodynamics has covered a large field, and the performances of full-scale machines have been compared with the results obtained with scale models in the wind channel with a view to ascertaining the relation between the wind forces in the two cases. Other wing experiments carried out relate to biplane and triplane wings, stress distribution under special conditions of flight, aspect ratio, form of wing tips, effect of "wash-out," best form and dimensions of ailerons, balanced ailerons for large machines, etc. Measurements of the distribution of pressure over the wings of a biplane in flight have been made at the R.A.E.

Notable progress has been made in the establishment of a correct airscrew theory and in its application to design, and a summary of this work is shortly to be published. Useful work has also been done towards the production of propellers of variable pitch. The distribution of velocity in the air entering a propeller, and in the slipstream, has been carefully investigated.

Progress is reported in respect of airplane stability, both in theory and practice. Methods have been developed for the application of stability calculations to the more complicated motions of an airplane and from the knowledge gained some of the earliest conceptions have been revised. It is also pointed out that the practice has been established in the trials of new airplanes at Martlesham Heath of taking records to determine their longitudinal stability.

The determination of the aerodynamic data required for the computation of stress distribution has proceeded steadily, and new methods of tests for application to the actual airplane or its parts have been devised. It is pointed out that it has been the practice to make a test to destruction at the R.A.E. of one airplane of each new type.

Turning to airships the report points out that while the progress in airship construction has probably been relatively greater than that made in respect of the airplane, the advance in the study of airship theory and in the methods of experiment in relation to airships has been less marked. The measurement of the head resistance of an airship body, even in the case of a model, has been found to present many experimental difficulties, and the information obtained cannot be said to be yet by any means complete. The step from model to full-scale cannot at present be made with any approach to the accuracy requisite. It is pointed out that research work in regard to airships is bound to be expensive, but it is hoped that the Committee will not be hampered in this highly important work by financial worries. Important progress has been made in the development of the theory of airship stability, and useful work has been carried out in connection with wind-screens and the mooring of rigid airships.

Experimental work in connection with kite balloons has led to important improvements in construction and performance.

While aerodynamic tests on seaplane models present no very distinctive features, a good deal of research has been carried out with floats and flying-boat hulls in the William Froude National Tank, resulting in the accumulation of a considerable amount of information for the guidance of designers. An interesting and important part of the work has been the investigation of the stability of a seaplane while planning, for which tests special apparatus was designed. Other tank experiments have included the determination of the best form of drogue to serve as a sea-anchor for airships.

Model experiments in the wind channel have been made in connection with the design of airplane carrier ships, mainly relating to the flow of air over the alighting deck, and the results have been confirmed by flying trials. An alternative scheme for an alighting stage consisting of a large number of longitudinal parallel wire ropes tensioned to as flat a catenary as possible, so forming a long flexible landing platform, has been suggested by Mr. F. W. Lanchester.

Extensive investigations have been carried out in connection with engines. It is claimed that the successful use of aluminum cylinders and pistons has been rendered possible by the researches on light alloys carried out at the N.P.L., the R.A.E., Birmingham University, and elsewhere with the close co-operation of the foundries experienced in such work. It is realized that much remains to be done to render the high-power aeronautical engine as reliable as those used for other forms of locomotion, and great part of the research work has been directed towards determining the causes of failure in practice, such as crankcase breakages, crankshaft failures, burning of valves, piston troubles, ignition, etc. The question of engine cooling has come in for a good deal of attention. This is an aerodynamic as well as an engine problem, and its solution must always be a matter of compromise. On air cooling a large amount of work has been done, and the radiator problem has been fully studied.

Another matter to which attention has been given is the determination of the loss of power with height, *i.e.*, with reduction of air density, and generally the testing of engines under high altitude conditions. Means of reducing the loss of power at a height have been investigated, especially the question of super-compression, and the use of a blower to maintain the air pressure.

The work in connection with light alloys has proceeded on two main, but very distinct lines: 1. Wrought alloys of high tensile strength for rigid airship construction and other aircraft work where they can replace steel with a saving in weight; and 2. Cast alloys which are needed for engine cylinders, pistons and crankcases. Since 1914 the Laboratory has been equipped on a semi-manufacturing basis and special attention has been given to heat treatment, and full details of the development of wrought alloys are to be published shortly. Many new alloys have been rendered available for various purposes in the future, and the metals used include aluminum, copper, zinc, tin, magnesium, iron, nickle, manganese, chromium, vanadium, cobalt and beryllium; aluminum is usually the main ingredient, but alloys with magnesium as a base have also been investigated.

Among other work carried out on aluminum alloys may be mentioned the production of thin sheet to replace fabric for wing covering; a satisfactory procedure for the manufacture of sheet of the requisite thickness has been developed at the N.P.L., and methods of fixing it to the wing have been devised.

Many meteorological problems have also been investigated among them one in connection with what has been described as a "wind barrage" met with by an airship attempting to cross the sea coast landwards in the neighborhood of St. Abb's Head. This has led to valuable experiments on the effect of eddies on the motion of an airship travelling through them. Another investigation is that which seeks to give protection to kite balloons from atmospheric electrical discharges.

Dopes and fabrics have continued to receive a good deal of attention, and important investigations have been directed to reducing the rate of deterioration, with loss of gas-tightness of airship fabrics, in the tropics. Considerable assistance has been rendered by the X Aircraft Depot, Aboukir, and it has been established that the deterioration is due almost entirely to the actinic radiation of sunlight, and that considerable protection can be afforded by introducing pigment into the outer layer of rubber.

The equipment of the Laboratory now includes one 3-ft., two 4-ft, three 7-ft. wind channels, and a new channel 7 ft. by 14 ft., is being installed for tests on large airplane models. In addition the R.A.E., has a 4-ft. and a 7-ft. wind channel and a second 7-ft. channel is being installed.

For Public Service for All Kinds of Aircraft

NEW YORK AIRDROME

Inspected and Passed

By a leading Pilot who has over 7,000 Hours Flying during 18 Years experience of Hangars, Airdromes and all their accessories. He states to his Principals that,

"YOU NEED GO NO FURTHER"

What more can we add? To those who need hangars and flying and parking facilities and will contract for it at once we are making the following terms:--

One or more Hangars each $150 per month, size 60x40 ft.

One or more Hangars each $200 per month, size 60x90 ft.

These low figures are quoted at this time to assist owners in the storage and care of their flying craft, and as an introduction of the New York Airdrome to the Flying public. Special Hangars will be erected to suit individual requirements, and all terms are subject to withdrawal or change without further notice.

Why Locate Your Field Inland?

We are on the water front and all modern aircraft need water landing for their pontoon attachments. Our location is on South Oyster Bay, Lond Island, New York; within easy reach of New York City (Pennsylvania Station) convenient to Rail and Road to the City.

Automobiles can reach it in forty minutes and have the Planes

Ready for Flying on Arrival

Management: Is composed of well known Fliers, Civilian, and Aeronautic Engineers, Experienced Photographers, Auto Garage Experts, Mechanics, etc. whose aim it will be to attain the maximum efficiency in every branch of Aeronautics.

Sport: Facilities are available to Patrons of the Airdrome as the locality is situated in the heart of a Boating, Swimming and Fishing Territory, and there will be special Flying Privileges for them and their friends. Flying Instruction will be at their disposal in the Dual Control Ships stationed at the Airdrome.

Hangar Space

May be contracted for in advance by sending in the number, size, and type of Aircraft, Pilots, Mechanics and other Personnel, present locality of Aircraft when and for what period the space is desired. All information may be had on application to

HAROLD A. DANNE

AERONAUTIC ENGINEER **41 PARK ROW, NEW YORK, N. Y.**

"The Plug that Cleans Itself"

Self-Cooling

Self-Cleaning

B G

Unbreakable

Non-fusible

"The Plug with the Infinite Spark"

THE BREWSTER-GOLDSMITH CORPORATION

33 Gold Street, New York City, U. S. A.

trade ALPRO mark

Alpro-Benzol used as combination fuel

by

J. L. Monoplane on recent record flight to Omaha and return

We are large manufacturers of

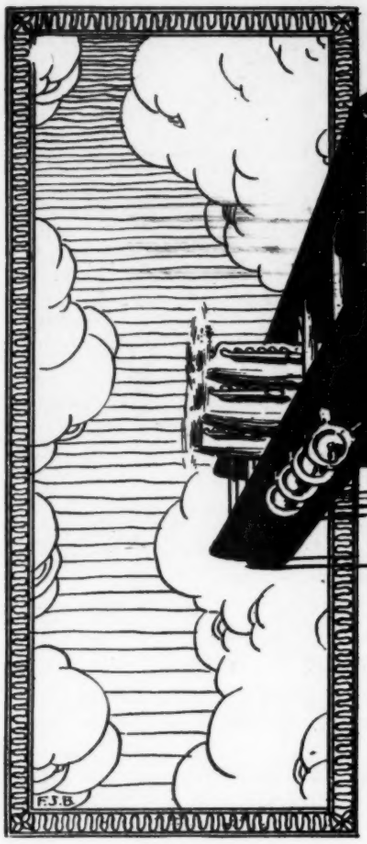
Nitrate Dope, Cellulose Acetate, Solvents, etc.

Alcohol Products Co.

Miner-Edgar Co. - Sales Agents

Plants
Monmouth Junction, N. J.
Newark, N. J.

Main Office
30 Church Street
New York



Contractors·to·the·Army,
·Navy·and·Air·Mail·Service

·L·W·F·Engineering·Co·,inc.,
·College Point· ·New·York·

THE HOME INSURANCE COMPANY NEW YORK

ELBRIDGE G. SNOW, President

Home Office: 56 Cedar St., New York

AIRCRAFT INSURANCE

Against the Following Risks

1. FIRE AND TRANSPORTATION.
2. THEFT (Of the machine or any of its parts).
3. COLLISION (Damage sustained to the plane itself).
4. PROPERTY DAMAGE (Damage to the property of others).

SPECIAL HAZARDS

Windstorm, Cyclone, Tornado—Passenger Carrying Permit—Stranding and Sinking Clause—Demonstration Permit—Instruction Permit

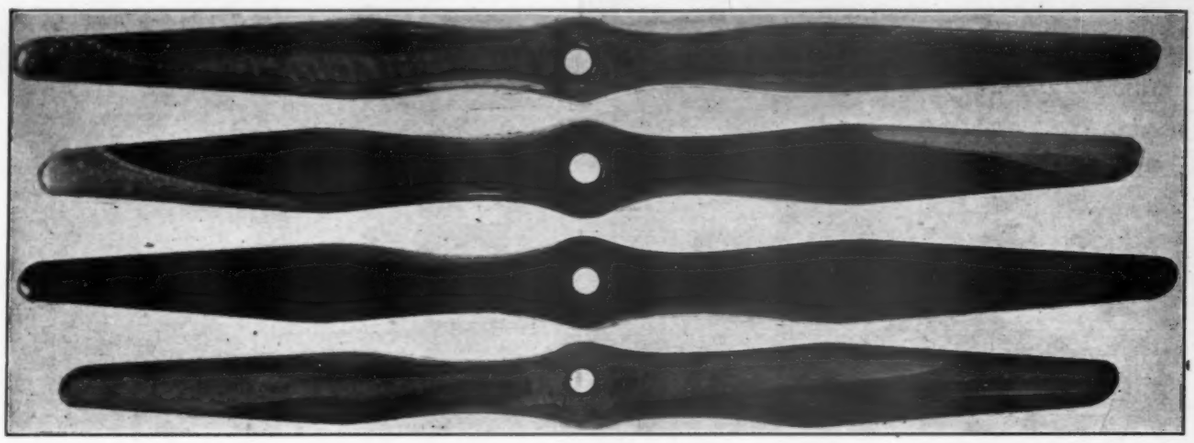
AGENTS IN CITIES, TOWNS AND VILLAGES THROUGHOUT THE UNITED STATES AND ITS POSSESSIONS, AND IN CANADA, MEXICO, CUBA, PORTO RICO AND CENTRAL AMERICA

Aircraft, Automobile, Fire and Lightning, Explosion, Hail, Marine (Inland and Ocean), Parcel Post, Profits and Commissions, Registered Mail, Rents, Rental Values, Riot and Civil Commotion, Sprinkler Leakage, Tourists' Baggage, Use and Occupancy, Windstorm

STRENGTH REPUTATION SERVICE

JACUZZI BROS., INC.

1450 SAN PABLO AVENUE, BERKELEY, CALIF., U. S. A.



We are now manufacturing more propellers than we did during the war.

Every aviator that uses them says he never had a better propeller for climbing and speed.

We have hundreds of letters of reputable fliers stating that our propellers of new design are the maximum in efficiency.

What motor and plane have you? In most cases we can make immediate delivery.

Aluminum Company of America

General Sales Office, 2400 Oliver Building
PITTSBURGH, PA.

Producers of Aluminum

Manufacturers of

Electrical Conductors
for Industrial, Railway and Commercial Power Distribution

also

Ingot, Sheet, Tubing, Rod, Rivets, Moulding, Extruded Shapes

also

Litot Aluminum Solders and Flux

CANADA
Northern Aluminum Co., Ltd., Toronto

ENGLAND
Northern Aluminium Co., Ltd., London

LATIN AMERICA
Aluminum Co. of South America, Pittsburgh, Pa.

FAIRCHILD CAMERAS

WE WISH TO ANNOUNCE

that

We are consolidating our laboratories, engineering, and executive offices, in order to meet the demand for the

Fairchild Aerial Cameras and Accessories

After July first, our address will be:

136--146 West 52 Street
New York City

Our Service Department is ready at all times to cooperate with you on your aerial photographic problems.

FAIRCHILD AERIAL CAMERA CORPORATION
136--146 West 52 Street
New York City

DEPENDABILITY

Diamond Fibre is a superior material for aeronautical use because it combines great strength with light weight.
Diamond Fibre is tougher than horn, almost as hard as iron, yet LIGHTER THAN ALUMINUM—unusually high in dielectric compression, shearing, and tensile strength—does not splinter, split, crack, break or crystallize under severe vibration—impervious to oil and grease and unaffected by ordinary organic solvents—actually improves with age.
Diamond Fibre readily takes any machining process and can be formed into the various shapes required. Furnished in sheets, rods, tubes, and special parts machined to your specifications.
We also manufacture Condensite Celeron, a new waterproof material of remarkable properties.
Samples, prices and complete information on request.
Dept. R.

Diamond-F

Diamond State Fibre Company
Bridgeport, Pa. (Near Philadelphia.)
In Canada, Diamond State Fibre Co. of Canada, Ltd., Toronto.

Edstrom Machinery Company

WAR DEPARTMENT
BUREAU OF AIRCRAFT PRODUCTION
AIRPLANE ENGINEERING DEPARTMENT
McCook Field, Dayton, Ohio, U. S. A.
REPORT Serial No. 646
on test of cable terminal connections made on the Edstrom Wire Wrapping Machine.

Finished Products of the Edstrom Machines

". . . It is to be noted that out of ten unsoldered specimens sizes 1/4" to 5/32", only one failed at a load below the rated capacity of the cable. The 3/16" specimens served with copper wire failed at loads averaging 71 per cent of the full strength of the cable."

Note: The nine cables standing 100 per cent were wrapped with the special strength wrapping wire we use on all our work.

". . . The Edstrom Wire Wrapping Machine . . . should be given a trial where such a machine is desired."

We can give you stronger, neater and better work at a great saving of cost to you.

Let us give you our price.

FACTORY:
Hunters Point 1835
REVIEW AVE. Bet. Fox and Marsh Sts., LONG ISLAND CITY
NEW YORK

PARAGON PROPELLERS

Highly Developed Dynopter Design
Special for J. N. Machines

The Economy Propeller Par Excellence

Price $45.00 F. O. B. Baltimore
For Metal Sheathing Add $12.00

These are a Special Development for O. X. Motors on J. N. Machines, now being made in large quantities and ready for immediate shipment on receipt of $15.00 deposit. C. O. D. for balance, with examination allowed before acceptance and safe delivery guaranteed. Every one bears the Paragon mark, with all that the mark implies. Get our General Booklet and List for other designs, etc. Write today.

AMERICAN PROPELLER & MFG. CO.
1261-9 Covington Street
Baltimore, Maryland, U. S. A.

"RYLARD"

THIS SPECIAL VARNISH was adopted by the British Air Ministry in 1916 as being the premier Varnish for Aircraft work. The whole of the output of "RYLARD" produced from our specially increased plant was taken by the Air Ministry and delivered to the various Aircraft manufacturers all over the British Isles, for use over doped fabric, and has given every satisfaction.

The most suitable Varnish
for
AEROPLANE PROPELLERS
STRUTS AND SKIDS
SEAPLANE FLOATS
DOPED FABRICS

It Dries Quickly, will not Bloom, Crack, or Blister, is Impervious to Oil, Petrol, Sea Water, etc., and is unaffected by Sun or Rain.

AMERICAN BRANCH:
Llewellyn Ryland Co. of America
64 East Van Buren Street, CHICAGO, U. S. A.

The "Bristol" Aeroplanes

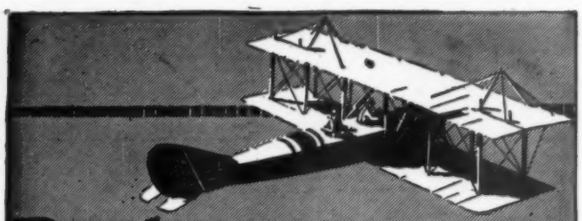
"Bristol" representatives enjoy a prestige and income that is the logical result of merchandising the highest grade aeroplane on the market today.

A limited number of contracts are still available, but naturally the caliber of the representative must be in keeping with the product.

If you think your organization can qualify, write us in detail.

WILLIAM G. RANELS
Representing
THE BRISTOL AEROPLANE CO., Ltd.
512 Fifth Avenue New York

45



Baker's A-A Castor Oil

Specially Refined for the Lubrication of AERONAUTICAL MOTORS

BAKER CASTOR OIL CO.
Founded 1857
The Oldest and Largest Manufacturers of Castor Oil in the United States
120 BROADWAY - - - NEW YORK

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

Are you building a hangar?

JOHNS-MANVILLE Corrugated Asbestos Roofing, used for the roofs and side walls of hangars, gives weather-proof protection of splendid durability because it is immune to the corrosive action of sea-air, smoke or acid fumes—and it never needs painting for its asbestos surface is amply able to resist any climate.

Write for information about Johns-Manville Corrugated Asbestos Roofing—you will probably find it peculiarly suited to your needs.

H. W. JOHNS - MANVILLE CO.
Madison Avenue at 41st Street, New York City
10 Factories—Branches in 64 Large Cities
For Canada:
CANADIAN JOHNS-MANVILLE CO., Ltd., Toronto

HAMILTON PROPELLERS

Hamilton Aero Mfg. Co., 679 Layton Blvd. Milwaukee, Wis.

For Your Flying ←Boats Use

Upward of 5,000 gallons of Jeffery's Patent Waterproof Liquid Glue has been used by the U. S. Navy and War Department and as much more by the various manufacturers of seaplanes having government contracts.

L. W. Ferdinand & Co.
152 Kneeland Street
Boston, Mass., U. S. A.

LEARN TO FLY

in old established school, under an instructor who has given instruction to more

AMERICAN ACES

than any other instructor.

Army Training Planes Used.
We Build Our Machines.

PRINCETON FLYING CLUB, Princeton, N. J.
WEST VIRGINIA AIRCRAFT CO., Wheeling, W. Va.
DAYTONA FLYING CLUB (Winter), Daytona, Fla.

THE PIONEER INSTRUMENT COMPANY

announces the removal of its office and factory to larger and more suitable quarters at

136 Havemeyer Street Brooklyn N Y

at the corner of South First Street. Will you not make a note in your file of this address so that there may be no delay in the receipt of your letters?

FREDERICK W. BARKER

REGISTERED PATENT ATTORNEY

2 RECTOR STREET NEW YORK

Telephone 4174 Rector *Over 30 Years in Practice*

PRESIDENT
AERONAUTICAL SOCIETY OF AMERICA
FROM 1915 TO 1919

SPECIALTY: Patent Claims That Protect

CLASSIFIED ADVERTISING

10 Cents a word, minimum charge $2.00, payable in advance. Address replies to box numbers, care AVIATION AND AERONAUTICAL ENGINEERING, 22 East 17th Street, New York.

CONSULTING AERONAUTICAL ENGINEERS

AN INDEPENDENT ORGANIZATION OF SPECIALIZED AERONAUTICAL ENGINEERS ENGAGED IN THE SCIENTIFIC AND PRACTICAL DEVELOPMENT OF AERONAUTICS BY CONSULTATION, DESIGN EXPERIMENTAL RESEARCH AND TESTING

ALEXANDER KLEMIN

22 East 17th Street New York

FOREIGN BUSINESS-GETTING RESULTS

A prominent accessory manufacturer, in a letter of June 14, 1920, says:

"We have received half a dozen inquiries in regard to our ——— from England and Belgium within the past three weeks as the result of our advertising in your Aeronautical publications beginning April 25th.

"We also received an order for ——— from England within 30 days of our beginning advertising.

"We consider this very prompt response to advertising from parties abroad."

(*Name of manufacturer and product furnished upon request*)

AVIATION AND AERONAUTICAL ENGINEERING
AIRCRAFT JOURNAL

THE GARDNER-MOFFAT CO., Inc.
22 E. 17 St. New York

Grand Rapids Vapor Kilns

are used by these aircraft concerns with absolute satisfaction.

Standard Aircraft Corporation
Fisher Body Corporation
American Propeller & Mfg. Co.
Alexandria Aircraft Corp.
Gallaudet Aircraft Corp.
Thomas-Morse Aircraft Corp.

Submit your drying problem to experts who make a specialty of kiln design and are prepared to furnish and install all equipment and instruments.

GRAND RAPIDS VENEER WORKS
Grand Rapids, Michigan Seattle, Washington

HALL-SCOTT

TYPE L-6
AIRPLANE ENGINES

Hall-Scott Motor Car Company
West Berkeley, California

AIRPLANE INSURANCE

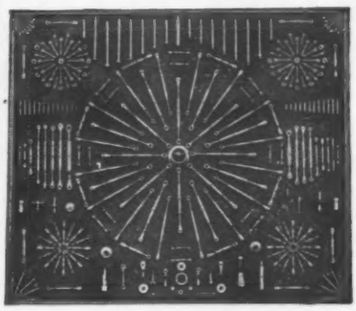
FOR THE

Manufacturer—Flyer

Fire—Collision—Damage to Property of Others
Legal Liability—Life—Personal Accident
Conservative Rates—Best Companies

PHONE—WRITE—WIRE

HARRY M. SIMON
Insurance Expert
81-83 Fulton St. New York, N. Y.



The pioneer manufacture of airplane parts made from bar stock. Any and everything pertaining to the manufacture of airplanes.

Any Quantity

A. J. MEYER MANUFACTURING CO.
819 John Street West Hoboken, N. J.

Flottorp Manufacturing Co.

AIRCRAFT PROPELLERS
Established 1912

213 Lyon St., Grand Rapids, Michigan

Contractors to United States Government

Warwick NON-TEAR *Aero-Cloth*

A SAFE CLOTH *for* FLYING

For Particulars Apply to

WELLINGTON SEARS & CO.
66 Worth Street, New York

INDEX TO ADVERTISERS

A
Aeromarine Plane & Motor Co. 460
Alcohol Products Co. 482
Aluminum Company of America. 484
American Propeller & Mfg. Co. 485

B
Baker Castor Oil Co. 486
Barker, F. W. 487
Brewster-Goldsmith Corp. 482
Bristol Aeroplane Co. Ltd. 486

C
Climax Molybdenum Co. 458
Coast Guard. 488
Curtiss Aeroplane & Motor Corp. 490

D
Diamond State Fibre Co. 485
Doehler Die-Casting Co. 487

E
Edstrom Machinery Co. 485

F
Fairchild Aerial Camera Corp. 484
Ferdinand & Co., L. W. 487
Flottorp Manufacturing Co. 488

G
Grand Rapids Veneer Works. 488

H
Hall-Scott Motor Car Co. 488
Hamilton Aero Manufacturing Co. 486
Home Insurance Co. 483

J
Jacuzzi Bros., Inc. 484
Johns-Manville Co., H. W. 486
Jones Motrola, Inc. 489
J. L. Aircraft Corp. 462

L
L-F-W Engineering Co., Inc. 483

M
Manufacturers Aircraft Ass'n. 491
Martin, The Glenn L., Co. 459
Meyer, A. J., Mfg. Co. 488
Mosler, A. R. 490

N
New Departure Mfg. Co. 464
New York Airdrome. 481

P
Pioneer Instrument Co. 487

R
Ranels, William G. 486
Ryland Co., Llewellyn, of America. 485

S
Simon, Harry M. 488

T
Thomas-Morse Aircraft Corp. 463

U
United States Rubber Co. 492

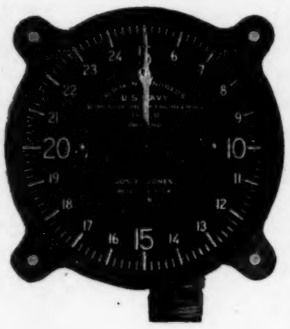
W
Wellington, Sears & Co. 488
West Virginia Aircraft Co. 487
Wright Aeronautical Corp. 461

JONES TACHOMETERS

Acknowledged by experts as the

"BEST BY TEST"

Jones Aeroplane Tachometer

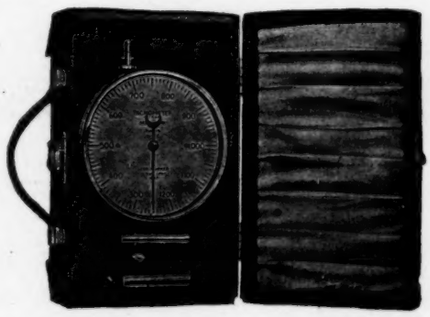


—was designed especially for the United States Navy Department for use in the war. Its splendid record of service, under all conditions, was demonstrated by the Famous Trans-Atlantic flight of the NC 1, NC 3 and NC 4. It is the lightest instrument of any type yet produced.

The Jones Aeroplane Tachometer comprises the Standard Jones Head, which is being widely used in commercial fields. This instrument is particularly adapted for use on special testing outfits, such as magneto and dynamometer test sets, etc. The dial is evenly spaced throughout, thus making possible quick and accurate readings of revolutions per minute.

The Jones Aeroplane Tachometer can be driven either by flexible shaft or belt, as preferred.

We have designed the *Jones Hand Tachometer* especially for portable use. This instrument has proven invaluable in *Cotton* and *Paper Mills* and *Machine*



Shops, etc. A special disc, one foot in circumference, can be supplied to show peripheral, or surface speed in feet per minute.

Send to-day for a report of test by the United States Bureau of Standards, and for our new booklet.

JONES-MOTROLA, INC.

31 West 35th Street New York

A. J. Fisk, Special Representative,
965-967 Woodward Ave., Detroit, Mich.

Curtiss

Member Manufacturers' Aircraft Association

SERVICE that Covers the Continent

"*Service* is the greatest thing in the world." When you *need* Service you want it *immediately*.

Service is the basis of the Curtiss sales policy. Every Curtiss Distributor maintains a Service Station.

CURTISS DISTRIBUTORS

Curtiss-Eastern Airplane Corpn., Philadelphia, Pa.
Curtiss Flying Station. Atlantic City, N. J.
America Trans-Oceanic Company, New York City
Curtiss Airplane Company of New England, Boston, Mass.
Curtiss-Johnson Airplane Company, Montgomery, Ala.
Memphis Aerial Company, Memphis, Tenn
Chattanooga Automobile Company, Chattanooga, Tenn.
Curtiss-New York Airplane Corporation, Buffalo, N. Y.
Curtiss-Iowa Aircraft Corporation, Fort Dodge, Ia.
Curtiss-Northwest Airplane Company, Minneapolis, Minn.
Lynchburg Air Service Corpn., Lynchburg, Va.
Curtiss-Kansas Aircraft Corporation, Topeka, Kansas
Curtiss-Humphreys Airplane Company, Denver, Colorado.
Curtiss-Southwest Airplane Company, Tulsa, Okla.
Syd Chaplin Aircraft Corporation, Los Angeles, Calif.
Curtiss Aeroplane and Motor Corporation, Chicago, Ill.
Curtiss-Wisconsin Airplane Company, Milwaukee, Wis.
Thompson Airplane Company, Detroit, Mich.
Grand Island Aero Company, Grand Island, Nebr.
Curtiss-Indiana Airplane Company, Kokomo, Ind.
Earl P. Cooper Airplane, Co., San Francisco, Calif.
Oregon, Washington & Idaho Airplane Co., Portland, Oregon
Floyd J. Logan Aviation Company, Cleveland, O.

CURTISS AEROPLANE *and* MOTOR CORPORATION

Sales Office: GARDEN CITY, LONG ISLAND, N Y.

167B

Factories: Garden City, L. I., and Buffalo, N. Y. Flying Fields, Training Schools and Service Stations: Garden City, Atlantic City, N. J., Newport News, Va., Miami, Fla., and Buffalo. Dealers and distributors in all parts of the United States. Special Representatives in Latin America, the Philippines and the Far East.

Mosler Aircraft Spark Plugs

Mosler Standardized Mica Aircraft Spark Plugs for All Airplane Engines Irrespective of Type or Fuel Used

Ordered in large quantities by the Bureau of Aircraft Production during the War.

Adopted by the U. S. Air Mail Service for the Fiscal Year 1920-21

Hold Notable Airplane, Automobile, Motor Boat and Motor Cycle Records.

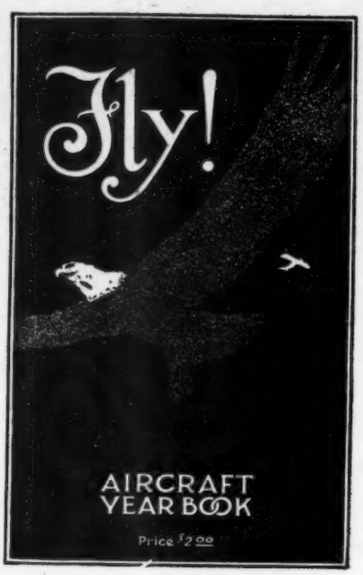
Passed Exceptional Bureau of Standards Tests.

Used on the Twelve High Compression Liberty Engines of the NC-1, NC-3 and NC-4 Seaplanes in the Trans-Atlantic Flight.

Used on the JL-6 All-Metal Monoplane in its Record Non-Stop Flight from Omaha to Lancaster, Pa., (1200 miles by air line in 10 hours 58 minutes) June 27, 1920.

A. R. Mosler Company

Mt. Vernon, New York



Blazing the Air Trail

Passenger and Commercial Airlines are being organized all over the country. The selection of air routes, good locations and the right kind of flying craft require time and thought --and consultation with recognized aeronautical authorities.

If You are Planning to
Go into Commercial Aviation
You Should Read

The Aircraft Year Book for 1920

Issued by the Manufacturers Aircraft Association, Inc.

Just a few interesting chapters in this book containing 335 pages of facts about flying. 80 pages of instructive photographs and numerous maps.

Read's Own Story of the Trans-Atlantic Flight.
Complete records of the
Aerial Mail *Sport Flying*
Forest Patrol *Passenger Lines*
Chronology of 1919 in Aviation
U. S. Army Air Service Victories
How the World has been two-thirds flown around in the past year.
List of Permanent and Emergency Landing Fields in the U. S.
Map of World's Air Routes
Map of U. S. Air Routes
Map of U. S. Landing Fields
Aircraft in Commerce and many other Interesting Facts.

Handsomely Bound in Cloth

THIS EDITION IS ALMOST EXHAUSTED--SEND $2.25 AT ONCE AND THE AIRCRAFT YEAR BOOK WILL BE SENT TO YOU POST PAID -- ADDRESS

THE GARDNER, MOFFAT CO.

HARTFORD BUILDING -- UNION SQUARE
22 EAST SEVENTEENTH STREET NEW YORK CITY

A New Standard of Aircraft Service

NECESSITY guided our war-time efforts in the production of UNITED STATES BALLOON FABRICS. Since then, our policy of faith has been backed by a continued zeal in application. As a result, to-day we have standardized UNITED STATES BALLOON FABRICS to that degree of genuine service which is reflected in all the products of the world's oldest and largest rubber manufacturer.

Inquiries concerning UNITED STATES BALLOON FABRICS and any rubber goods used in aeronautics should be directed to the Aircraft Department, 1790 Broadway, New York City.

United States Rubber Company

UNITED STATES RUBBER COMPANY
US
RUBBER SYSTEM
AND ASSOCIATED COMPANIES